

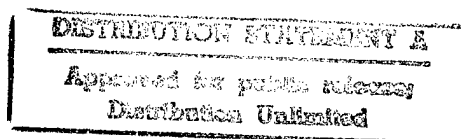
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# ***JPRS Report***

# **Science & Technology**

***China***



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# Science & Technology China

JPRS-CST-91-004

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### **Head-Up Display Weapons Aiming System Developed**

91P60088 Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 29 Dec 90 p 1

[Article by Cheng Meimei [4453 4168 4168]: "Aircraft Head-Up Display Weapons Aiming System Developed"]

[Summary] The aircraft head-up display weapons aiming system developed by the Ministry of Aeronautics & Astronautics Industry's Research Institute 613 fills a domestic void, and its installation in warplanes forms a solid basis for raising combat effectiveness. This advanced aerial fire-control system, combining an electro-optic display with a digital computer, reduces line-of-sight slewing and improves the weapons projection format to realize better aiming accuracy, improved flight operating conditions, and enhanced flight safety.

### **Activities of China Aeronautical Radio Electronics Research Institute Highlighted**

91FE0132A Beijing GUOJI HANGKONG [INTERNATIONAL AVIATION] in Chinese 5 Oct 90 p 11

[Text] The China Aeronautical Radio Electronics Research Institute (CARERI) is a research organization of the Ministry of Aeronautics and Astronautics Industry specializing in the research and development of avionics system technology and integrated systems. Current research programs of the institute include flight management systems for commercial airplanes, airworthiness technology, and global positioning system (GPS) technology. This institute is an overseas member of the U.S. Radio Technology Committee for Aviation (RTCA), and also a participant of the International Organization for Standardization. Located within the institute is an authorized maintenance and repair station for Marconi instruments and gauges.

The institute has the following products on display at this exhibit:

1. The 210 Doppler navigation system is a structurally simple, small and lightweight system equipped with automatic magnetic error correction capability and digital interface. It can be used on attack aircraft, transport, and bombers for displaying such parameters as ground-speed offset, current position, estimated flight course, remaining distance, remaining time, wind speed and direction, yaw angle and magnetic error; the navigation parameters are transmitted to other systems using the ARINC 429 digital data format. It can also operate in conjunction with the flight control system to provide automated navigation. The system has already been installed on various aircraft for flight test.

2. The M805 flight-course/glideslope field tester/monitor is designed to test airport instrument landing systems and to monitor flight-course beacon stations and

glideslope beacon stations. It can provide precise measurement of the percentage modulation and the sum and difference of percentage modulation; it can also provide estimates of the relative radiation field intensity. Its frequency coverage is in compliance with regulations of the International Aviation Organization. Based on field experience at major commercial airports, the performance of this unit has been shown to match that of similar products built abroad.

3. The 108A VHF omni-directional beacon/instrument landing receiver is designed to provide flight information such as the deviation angle from the designated flight course, the omni-directional bearing angle and the relative bearing angle to assist the pilot in maintaining the correct flight course. During landing, it can provide indicators of deviations from the assigned course and from the glide path to assist the pilot in executing a safe landing. This unit has been used extensively on commercial airplanes; its performance has proved to be stable and reliable, and compares favorably with similar products built overseas.

4. The NDB-200 nondirectional beacon station is a fixed intermediate-frequency radio navigation station and an essential piece of equipment of airport operation. This unit has two receivers whose operations can be alternated and remote-controlled; no operator on-duty is required. It can be used by military and commercial airports, on large warships, by harbor authorities, and on oil-drilling platforms. Its performance indices match those of similar products built overseas.

5. The flight planning system (FPS) is an operational and management tool used by airline companies to satisfy CCAR/FAA/CAA airworthiness requirements. It provides computerized flight plans and other control information to the users to achieve optimum operating efficiency.

6. The digital surge-prevention/ $T^*_4$  temperature control unit is part of the surge-prevention system of the engine; it is designed to accomplish both interlocking surge-prevention and encountering surge-prevention, and also control  $T^*_4$  temperature at the same time.

### **Products of Luoyang Institute Introduced**

91FE0132B Beijing GUOJI HANGKONG [INTERNATIONAL AVIATION] in Chinese 5 Oct 90 p 12

[Article by Wang Chonggui [3769 1504 6311]]

[Text] The Luoyang Institute of the Ministry of Aeronautics and Astronautics Industry is a multi-discipline research institute specializing in the study of fire control system theory and electro-optic equipment. It has an air-combat simulator and many other laboratories containing several thousand pieces of instruments and equipment.

This institute has the following products on display:

1. The optical target-aiming device is an autonomous aiming device which consists of five segments: an optical display unit, a rate gyro, an electronic analog computer, a servo-amplifier, and a static pressure sensor. This device can be used in conjunction with radars and radar ranging equipment to meet the aiming requirements of aircraft guns, air-to-ground rockets, and infrared missiles. Its performance can match that of similar products built overseas. The total weight of the device is less than 23 kg.

2. The digital horizontal-display fire control system is currently in the final design stage and in small-scale production. It has the capability of interfacing with inertial navigation systems, atmospheric-data computers, radars, digital guidance equipment, Tacan's, gyro-compasses, and guided weapon systems. The system has two major components: the pilot display unit (PDU) and the electronic unit (EU); special interface ports can also be installed to accommodate the needs of the weapon system. Its field-of-view is greater than  $24^\circ$ , and the brightness level of its symbol display, at 5,140 candela/m<sup>2</sup>, is the same as that of foreign products. The system has five operational modes for navigation, five modes for air-to-air combat, and four modes for air-to-ground attack; these modes can be used for LCOS, CCIL, CCIP, CCRP, medium-range missile intercept, inertial navigation and landing; they are also compatible with the operations of aircraft guns, rockets, bombs and medium-range missiles and combat missiles. The system is powered by the d.c. and a.c. power supply unit onboard the aircraft. The total weight of the PDU and the EU is only 25 kg. The electronic components of the system are equipped with cooling fans and can operate over a temperature range from  $-45^\circ\text{C}$  to  $+60^\circ\text{C}$ . Except for the CRT display unit, the mean-time-to-failure of the system exceeds 700 hours. The performance of the display unit also compares favorably with that of similar products built overseas.

3. The helicopter horizontal-display fire control system is used for the deployment of aircraft guns, rockets, and missiles; it can operate in conjunction with antitank stabilized aiming devices and helmet aiming devices to carry out air-to-ground and air-to-air attack missions. The system is highly compact, and has removable viewing glasses so it can be used for noncombat missions. It has a pitch field-of-view of  $25^\circ$ , and a horizontal field-of-view of  $20^\circ$ ; its total weight is 9 kg. The system has three major segments: the pilot display unit, the electronic components, and the control box.

4. The helmet aiming and display system can be used on fixed-wing combat aircraft and helicopters, and can also be used on warships and in air defense systems. In addition to providing displays for navigation and air attacks, it can also provide the capability of fast and accurate target acquisition for weapon systems and sensor systems. This system can be easily installed on most aircraft and has many desirable features such as

large field-of-view, light weight, ease of operation, absence of physical constraint, and ready interface with other systems of the aircraft. It has a display field-of-view of  $14^\circ$  and has no restriction on head movement in a conventional cockpit environment. The added weight to the helmet is less than 0.26 kg, and the total system weight is 18 kg.

This institute is developing an integrated fire control system, and has implemented the horizontal display technology in the automobile industry by developing a horizontal display unit for automobiles.

### Estimating Length of Space Tether in Container Recovery Operation

91FE0131 Beijing ZHONGGUO KONGJIAN KEXUE JISHU [CHINESE SPACE SCIENCE AND TECHNOLOGY] in Chinese Vol 10 No 4, Aug 90 pp 44-47

[Article by Zhu Renzhang [2612 0088 3864], Beijing Institute of Spacecraft Systems Engineering]

[Abstract] The feasibility of using a space tether to replace chemical propulsion in container recovery operations is analyzed, and the procedure for estimating the length of the space tether is presented.

The potential of using a space tether in aerospace applications has attracted a great deal of interest. It has been suggested<sup>(1)</sup> that a descending space tether can be used to replace chemical propulsion device to bring test samples from a space station (Sky Lab) back to earth, and to carry waste materials into the dense atmosphere to be incinerated. In this article, a preliminary analysis of the feasibility of this operation and the procedure for estimating the length of the space tether are presented.

#### I. Operational Procedure

First, the test sample is placed in a recoverable container which is attached to one end of the space tether; the other end is rigidly fastened to the tether extension and retrieval device on the space station, so that the tether is extended toward the earth. Under the action of the gravity gradient, the tether would stretch in a direction along the gravity line. When the tether is stretched to a certain length, i.e., when the container reaches a certain altitude, it is released from the tether and placed in a transfer orbit which will carry the container into a re-entry orbit. At the same time, the space tether is retrieved by the space station for future use.

#### II. Motion of the Center of Mass of the System

The system which consists of the space station, the recoverable container and the space tether is called the tether satellite system. A number of authors, including the present one<sup>2</sup> have analyzed the motion and the control of the system during the stretching, retrieval and holding stages; in most applications, stability of motion is achievable. Preliminary analysis by this author indicates that if the holding stage continues for a long period

of time (e.g., 20 hours), the accumulated effect of aerodynamic drag may cause the system to become unstable; however, during the short period following tether extension, the system is quite stable. During this period, we can choose the precise moment of releasing the container. In this article, an analysis of the motion of the recoverable container starting from the point of release is presented.

Assume that the mass of the tether is uniformly distributed along the line connecting the space station and the container. In an earth-centered coordinate system, the coordinates of the center of mass of the system can be expressed as<sup>3</sup>:

$$\vec{r}_o = (\vec{r}_s + K\vec{r}_p) / (1 + K) \quad (1)$$

$$\text{where } K = \left(m_p + \frac{m_t}{2}\right) / \left(m_s + \frac{m_t}{2}\right) \quad (2)$$

Here,  $\vec{r}_s$ ,  $\vec{r}_p$  are the position vectors of the space station and the container respectively;  $m_s$ ,  $m_p$  and  $m_t$  are respectively the mass of the space station, the container and the space tether. Equation (1) implies that the tether satellite system can be represented by a double-mass model where the masses are equal to  $(m_s + m_t/2)$  and  $(m_p + m_t/2)$  respectively. The acceleration of the center of mass is given by the following expression<sup>3</sup>.

$$\begin{aligned} \ddot{\vec{r}}_o &= (\ddot{\vec{r}}_s + K\ddot{\vec{r}}_p) / (1 + K) \\ &= -\mu \vec{r}_o / r_o^3 [1 + O(L^2/r_o^2)] + (\vec{F}_s + \vec{F}_p) / m \end{aligned} \quad (3)$$

where  $\mu$  is the earth gravitational constant;  $L$  is the tether length;  $\vec{F}_s$ ,  $\vec{F}_p$  are the disturbing forces acting on these two masses;  $m$  is the sum of the two masses (i.e., total system mass). Since  $L \ll r_o$ , we can neglect  $O(L^2/r_o^2)$ ; thus, one can justify expressing the motion of the system center of mass by the osculating trajectory determined by  $\vec{r}_o$  and  $\dot{\vec{r}}_o$ . If the disturbing forces are also neglected, then the trajectory of the center of mass is a special conic section which may be either a circle or an ellipse. For simplicity, let us assume that at the point of container separation from the tether, the trajectory of the system center of mass is a circle with a radius  $a_c$ . Its velocity is:

$$V_c^2 = \mu/a_c \quad (4)$$

### III. Position and Velocity of the Container

The distance between the container and the center of mass of the system  $L_p$  can be expressed as:

$$L_p = L / (1 + K) \quad (5)$$

Let the distance between the container and the center of earth be denoted by  $r_1$

$$r_1 = a_c - L_p \quad (6)$$

It can be shown from dynamic analysis of the tether satellite system that the container and the space station have the same angular velocity as the system center of mass. Thus, if the container velocity is denoted by  $V_1$ , then

$$V_c/a_c = V_1/r_1 \quad (7)$$

### IV. Trajectory of the Container After Release From the Tether

After the container is released from the tether, the tension acting on the container vanishes; the only force acting on it is the earth gravitational force (ignoring disturbing forces such as atmospheric drag). Therefore, the container enters into an elliptical transfer orbit which will carry it toward the re-entry orbit for return back to earth. Let the semi-major axis of the elliptical orbit be  $a$ , then the relationship between the velocity at the point of release and  $a$  is given by the formula:

$$V_1^2 = \mu[2/r_1 - 1/a] \quad (8)$$

From equations (7), (8), and (4), one can easily derive the following expression for  $a$

$$a = \frac{r_1 a_c^2}{2a_c^2 - r_1^2} \quad (9)$$

For simplicity, we shall introduce dimensionless quantities where  $a_c$  is chosen as the length unit; these quantities are denoted by adding a short bar over the corresponding variables. Thus, equation (9) becomes:

$$\bar{a} = \frac{\bar{r}_1}{2 - \bar{r}_1^2} \quad (10)$$

Since  $\bar{r}_1$  is less than 1, it follows that  $\bar{r}_1$  is greater than  $\bar{a}$ ; this means that the point of release is the apogee of the orbit. Let the orbit eccentricity be denoted by  $e$ , then

$$e = \frac{\bar{r}_1}{\bar{a}} - 1 = 1 - \bar{r}_1^2 \quad (11)$$

Also, let  $r_2$  be the radial distance at the perigee of the orbit

$$\bar{r}_2 = \bar{a}(1 - e) = \frac{\bar{r}_1^4}{2 - \bar{r}_1^2} \quad (12)$$

Noting the fact that  $K$  approximately equals 0,  $L/a$  is much less than 1, one can easily derive the following linear approximations:

$$a = a_c - 4L \quad (13)$$

$$e = 3L/a_c \quad (14)$$

$$r_2 = a_c - 7L \quad (15)$$

#### V. Relationship Between the Re-Entry Altitude, Re-Entry Angle and the Container Release Altitude

Let the re-entry altitude be  $H_o$ , which can generally be assumed to be 100 km. When the container drops below the altitude  $H_o$ , aerodynamic effects must be considered, and the two-body approximation is no longer valid. The re-entry trajectory should be calculated either by approximate analytical formulas where aerodynamic forces (i.e., drag and lift) are taken into account, or by numerical integration.

The flight path angle at the re-entry altitude (i.e., the subtended angle between the velocity vector and the local horizon; it is positive when the velocity vector is below the local horizon) is called the reentry angle, denoted by  $\alpha_o$ . In general,  $\alpha_o$  is quite small (of the order of  $0.05^\circ$ ). The choice of  $\alpha_o$  depends on a number of factors such as aerodynamic loading, aerodynamic heating and return range; it is a topic of re-entry orbit design and therefore beyond the scope of this article. For the present analysis, it is assumed at  $\alpha_o$  is given.

Let

$$\bar{r}_o = (R + H_o)/a_c \quad (16)$$

where  $R$  is the earth radius, whose average value is 6371 km.

The radial distance  $r_o = R + H_o$  and the velocity  $V_o$  at the point of re-entry are related by the equation:

$$V_o^2 = \mu[2/r_o - 1/a] \quad (17)$$

From the area integral, one can obtain the following expression:

$$r_o V_o \cos \alpha_o = \sqrt{\mu a (1 - e^2)} \quad (18)$$

From equations (17), (18) and (10), (11), an expression for  $\alpha_o$  as a function of the tether length can be derived.

$$\cos^2 \alpha_o = \frac{\bar{r}_1^3}{\bar{r}_o [2\bar{r}_1 - 2\bar{r}_o + \bar{r}_o \bar{r}_1^2]} \quad (19)$$

The relationship between  $r_1$  and  $H_o$ ,  $\alpha_o$  can also be represented by the following equation:

$$\begin{aligned} \bar{r}_1^3 - (\bar{r}_o^2 \cos^2 \alpha_o) \bar{r}_1^2 - 2(\bar{r}_o \cos^2 \alpha_o) \bar{r}_1 \\ + 2\bar{r}_o^2 \cos \alpha_o = 0 \end{aligned} \quad (20)$$

The length of the space tether can be determined by solving the above equation. Let  $x = L_p/a_c$ , then  $\bar{r}_1$  can be expressed as:

$$\bar{r}_1 = 1 - x \quad (21)$$

By substituting equation (21) into equation (20), a fifth-order equation for  $x$  is obtained. Since  $x \ll 1$ , we can neglect higher order terms in the equation and retain only the first-order terms to arrive at an approximate solution of  $x$ :

$$x = \frac{1 - (2 - \bar{r}_o) \bar{r}_o \cos^2 \alpha_o}{5 - (2 + 3\bar{r}_o) \bar{r}_o \cos^2 \alpha_o} \quad (22)$$

The approximate solution can be substituted back into the equation for the higher terms to produce an improved approximate solution. By repeating this iterative procedure, a high-accuracy solution of  $x$  can be obtained.

#### VI. Estimating the Length of the Space Tether

By defining

$$\bar{R} = R/a_c \quad (23)$$

and using  $r_2$  to estimate the tether length, we should have

$$\bar{R} < \bar{r}_2 < \bar{r}_o \quad (24)$$

As pointed out earlier, for the present problem  $m_s$  is much greater than  $m_p$ ,  $m_t$ , hence  $K$  approximately equals 0, or  $L_p$  approximately equals  $L_o$ . Also since  $L/a_o$  is much less than 1, a first-order estimate would be sufficiently accurate; thus, from equation (24), we have

$$\frac{1 - \bar{r}_o}{4 + 3\bar{r}_o} < \frac{L}{a_o} < \frac{1 - \bar{R}}{4 + 3\bar{R}} \quad (25)$$

In general, the re-entry angle  $\alpha_o$  for most re-entry trajectories is close to zero (e.g.,  $0.05^\circ$ ); thus, when the container approaches the perigee of the transfer orbit, it is separated from the transfer orbit by aerodynamic forces, and enters into the reentry orbit (i.e., after this point, the velocity direction is always below the local horizon). Therefore, in general, we have

$$\frac{L}{a_o} \approx \frac{1 - \bar{r}_o}{4 + 3\bar{r}_o} \quad (26)$$

hence, the length of the space tether is given approximately by:

$$L \approx \frac{(R + H_s)(H_s - H_o)}{4(R + H_s) + 3(R + H_o)} \quad (27)$$

where  $H_s$  is the altitude of the circular orbit of the space station.

As an example, if  $H_s = 450$  km,  $R = 6371$  km,  $H_o = 100$  km, then the length of the tether is equal to or approximately equal to 51.12 km; its maximum length does not exceed 66.15 km.



## VII. Concluding Remarks

In container recovery operation, it is feasible to use space tether instead of chemical propulsion device to place the container into reentry orbit. The application of space tether will undoubtedly reduce operational costs. Based on the dynamic analysis of the tether satellite system and the preliminary analysis of this article, no unsurmountable problems have been discovered; therefore, it seems worthwhile to conduct an in-depth study of this application.

### Footnotes

\*—Arrow over letter

\*\*—One dot over arrow over letter

\*\*\*—Two dots over arrow over letter

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**Laser Gyro Prototype Passes Acceptance Check**

91P60097a Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
28 Dec 90 p 1

[Article by Mao Liangcai [3029 5328 2088]: "Laser Gyro Engineering Prototype Passes Acceptance Check"]

[Summary] The internal-cavity-type four-frequency differential laser gyro miniaturized prototype and subsidiary apparatus developed by a research team led by University of Science & Technology for National Defense professor Gao Bolong [7559 0130 7893] passed acceptance check on 2 December in Changsha, and is about to be installed into a complete inertial navigation system for strapdown testing. The laser gyro is a new-generation type of inertia-sensitive device with many advantages such as high accuracy, stable performance, compactness, light weight, and low cost.

**More Advances in Millimeter-Wave Technology Described**

91P60097b Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 7 Jan 91 p 1

[Article by Xie Ning [6200 1337]: "New Advances Achieved in Millimeter-Wave Technology Research"]

[Summary] Five technical achievements in millimeter-wave research realized at Qinghua University's Electrical Engineering Department—a "W-band six-port reflectometer" (a sub-project of the NSFC-funded project "millimeter-wave-spectrum resources development"), a W-band aperiodic broadband detector, a programmable attenuator, a dielectric-waveguide directional coupler, and a fixed mismatched load—passed expert technical appraisal the other day.

Millimeter-wave studies are at the cutting edge in science and technology today, and within them six-port technology—advanced in the 1970's as a new technology integrating computers with microwave measurement technology—has been studied since 1984 at Qinghua University's EE Department; various six-port systems in frequency ranges from the centimeter-wave band to the millimeter-wave band have been developed at this university. The technical experts appraised the newly developed equipment—which uses all-domestically-made components and devices throughout—as meeting 1980's international standards.

**Optical and Electrical Properties of Sb-doped Weakly P-type Hg<sub>1-x</sub>Cd<sub>x</sub>Te Crystal**

40100026B Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese Vol 9 No 5, Oct 90 pp 359-364

[English abstract of article by Wang Jue, Department of Physics, Tongji University, Shanghai, 200092, China; Huang Changhe, Materials Science Institute, Fudan University, Shanghai, 200433, China; Liu Jiming, Yu Zhenzhong, Tang Dingyuan (Shanghai Institute of Technical Physics, CAS, Shanghai, 200083, China; The Project supported by National Natural Science Foundation of China)]

[Text] By using the effect of impurity segregation, Sb-doped weakly P-type HgCdTe crystal is produced. The electrical property measurement of the doped material down to low temperatures is performed with ionization energy determined. The optical absorption and the I-V characteristics of the PN junction of Sb-doped material are investigated. The properties of Sb-doped material are compared with those of undoped one. The results indicate that good-quality devices can be fabricated using Sb-doped material as substrates.

**Spectral Distribution of Photo-Ionization Cross Sections for EL2 Level in Undoped Semi-Insulating GaAs**

40100026A Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese Vol 9 No 5, Oct 90 pp 345-350

[English abstract of article by Zhu Yonggang and Sun Henghui; (Physics Department, Fudan University, Shanghai, 200433, China; The Project supported by the Science Foundation of the Chinese Academy of Sciences (MS received 11 Aug 89, revised 12 Jan 90)]

[Text] The spectral distribution of photo-ionization cross sections  $\sigma_n^0 \cdot h\nu$  for the EL2 level in undoped LEC [liquid-encapsulated Czochralski-grown] semi-insulating GaAs is measured at different temperatures using constant-current photoconductivity. Three steps have been clearly found in the spectra. The spectral shape of all  $\sigma_n^0 \cdot (h\nu)$  curves appears to be related to the electron transitions from EL2 level to the  $\Gamma$ , L, X minima of the conduction band. The theoretical calculation agrees well with the experimental data; moreover, the physical parameters of EL2 level, such as binding energy,  $E_T$ , Frank-Condon shift  $d_{FC}$  and extension length of wave function  $\alpha^{-1}$ , have been obtained.

**Chromium Metallization Mechanism and Joining of Silicon Carbide Ceramics**

40090006A Beijing GUI SUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 18 No 5, Oct 90 (manuscript received 6 Nov 89) pp 393-399

[English abstract of article by Pan Yubai, Jiang Dongliang and Tan Shouhong; Shanghai Institute of Ceramics, CAS]

[Text] Cr metallization mechanism and joining technology of SiC-SiC-Cu are studied. According to thermodynamic calculation and considering that the physical-mechanical properties of Cr are similar to SiC, Cr was selected as an active metal.

For the optimum joining process, SiC was metallized by Cr at 1000-1250°C in vacuum, and then the SiC bodies were brazed. The bond strength was measured by means of four-point bending test; the average value is 103 MPa(RT), and the maximum is 140 MPa.

Structure of the joining surface was examined by SEM, metallography, AES and X-ray diffraction. It is found that Cr has been diffused into the SiC matrix and a reaction layer exists on the intersurface, on which  $Cr_3C_2$  is formed and at the same time Si escapes. The  $Cr_3C_2$  formed is beneficial to the joining of SiC-SiC and SiC-Cu.

**Research on Synthesis of Luminescent Glass-Ceramic Materials by Sol-Gel Method**

40090006B Beijing GUI SUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 18 No 5, Oct 90 (manuscript received 26 Oct 89 pp 393-399

[English abstract of article by Lin Bin, Xiao Hong, Zhang Weigang and Guan Shiquan; Institute of Materials Science, Jilin University)

[Text] The luminescent glass-ceramics material of  $CaO-SiO_2:Eu^{3+}, Bi^{3+}$  was prepared at low temperature by sol-gel method. The transition process from sol to gel was studied, and the influences of pH, water content of the original solution on gelation time, porosity, apparent density and surface area were examined. Small-angle X-ray scattering was used to investigate the different catalyzing mechanisms of acid and base in gelation process. The gelation-crystalline process was investigated by using XRD, IR spectrum and TG-DTA. The luminescent properties of luminophor and the effect of  $Bi^{3+}$  on the sensitization of  $Eu^{3+}$  were observed by studying their emission and excitation spectra.

**Study on Hot-Pressing Processing of SiC Fiber/LAS Glass-Ceramic Composite**

40090006C Beijing GUI SUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMIC SOCIETY] in Chinese Vol 18 No 5, Oct 90 (manuscript received 23 Oct 90 pp 393-399

[English abstract of article by Wang Xiaoguang, Jin Zongzhe and Zhou Ao; China Building Materials Academy]

[Text] Hot-pressing process of Nicalon SiC/LAS glass-ceramic composite is studied. After tests, four factors, i.e., hot-pressing temperature, time, pressure and heat treatment time at 950°C and three levels are selected for the orthogonal-design experiment  $L_9(3^4)$ . The effects of

these factors on the composite density, strength, toughness and the strength of fiber extracted from composite are analysed with SEM, TEM. The optimal process parameters and high-quality Nicalon SiC fiber/LAS glass-ceramic composite with high strength (612MPa) and toughness ( $15\text{MPa} \times \text{m}^{1/2}$ ) are obtained.

**A New Compound  $\text{K}_4\text{CuNb}_8\text{O}_{23}$  and Isomorphism Replacement Between  $\text{Cu}^{2+}$  and  $\text{Nb}^{5+}$**

40090006D Beijing GUI SUANYAN XUEBAO  
[JOURNAL OF THE CHINESE CERAMIC  
SOCIETY] in Chinese Vol 18 No 5, Oct 90 (manuscript  
received 14 Apr 90 pp 393-399)

[English abstract of article by Wu Bolin, Yuan Runzhang, and Lu Qinxue; Wuhan University of Technology]

[Text] A new compound was found in the system  $\text{K}_2\text{O}-\text{CuO}-\text{Nb}_2\text{O}_5$ ; chemical analysis shows that the molecular formula of the compound is  $\text{K}_4\text{CuNb}_8\text{O}_{23}$ . Single crystal of the synthetic compound is transparent and of green color with needle-like or long-thin schistose shape, its

index of refraction  $n_o=2.25$ , and its density  $d_{\text{obs}}=4.47\text{g}/\text{cm}^3$ . The compound is grown in the range of 1050-1170°C and its melting point is 1170°C. X-ray diffraction measurement shows that the crystal of the compound belongs to tetragonal system with space group  $P4/\text{mbm}$  and cell parameters  $a = b = 12.64$  Angstroms,  $c = 3.99$  Angstroms. It was further discovered that in the ternary system  $\text{K}_2\text{Nb}_4\text{O}_{11}$ , the composition of  $\text{Cu}^{2+}$  and  $\text{Nb}^{5+}$  varies in a certain extent in the formation of a series of solid solution. The X-ray powder pattern and intensity distribution of the series of solid solution are similar to those of  $\text{K}_4\text{CuNb}_8\text{O}_{23}$  and  $\text{K}_2\text{Nb}_4\text{O}_{11}$  and all of them belong to tetragonal system. Their lattice parameters vary with the composition of  $\text{Cu}^{2+}$  and  $\text{Nb}^{5+}$  from 12.64 Angstroms to 12.57 Angstroms and  $c$  from 3.99 Angstroms to 3.976 Angstroms. In fact, it is an isomorphism replacement between  $\text{Cu}^{2+}$  and  $\text{Nb}^{5+}$ . For all of the compounds in the system  $\text{K}_2\text{O}-\text{Nb}_2\text{O}_5$ , the condition of substitution is that  $\text{Cu}^{2+}$  can get into crystal lattice to form a ternary compound solid solution of  $\text{K}_2\text{O}-\text{CuO}-\text{Nb}_2\text{O}_5$  only when the atomic ratio of  $\text{Nb}^{5+}$  to  $\text{K}^+$  is more than 1.83.

### **The Effect of QingshuanMei on Focal Cerebral Infarction of Rats**

40091005B Nanning SHEZHI [JOURNAL OF SNAKE]  
in Chinese Vol 2 No 3, Sep 90 pp 7-11

[English abstract of article: "The Effect of QingshuanMei on Focal Cerebral Infarction of Rats"]

[Text] We induced focal cerebral infarction of rats by photochemical method and observed the effect of QingshuanMei. The experimental rats were divided into three groups: normal control, untreated cerebral infarction and treated cerebral infarction with QingshuanMei. The rats were treated for 5 days with 0.25 $\mu$ g/kg/day of QingshuanMei. The spontaneous brain electrical activity of treated rats improved significantly, light and electron-microscope showed the pathological changes were more obvious mild, and there were prominent gliosis at the border of focus, plasma fibrinogen reduced close to normal level. In 48 hours, average brain water percent of treated rats was 75.72  $\pm$  1.42 percent, significantly decreased to compare with untreated ones (79.22  $\pm$  0.25 percent). Those results suggested that focal cerebral infarction was treated early with QingshuanMei that would improve significantly brain electrical activity, morphological changes, and reduced brain edema. [sentence as published] There are beneficial effects to treat focal cerebral infarction with QingshuanMei.

### **Isolation and Determination of Cytotoxic Component From the Venom of Agkistrodom Halys Brevicaudus Stejneger**

40091005A Nanning SHEZHI [JOURNAL OF SNAKE]  
in Chinese Vol 2 No 3, Sep 90 pp 4-6

[English abstract of article by Sun Yihong, et al. of the Department of Medical Experiment, General Hospital of Shenyang Military District, Shenyang, China, 110015]

[Text] A highly active cytotoxic component was separated from the venom of Agkistrodom halys Brevicaudus stejneyer by means of DEAE A50 ion exchange and sephadex-G200 Gel chromatography. The component can kill some tumour cells in vitro non-specificity, but there were differences between the sensibility of tumour cells. It can also destroy normal cell in vitro, but compared with the tumour cells, sensibility of normal cell was lower. When heated up to 56°C for 30 minutes or restored at 4°C and 20°C respectively for 4 months, the component remained active and in the condition of PH < 4 or PH > 9, entirely inactive.

Key words: Agkistrodom halys; venom; cytotoxin.

### **First Non-Fusion Rice Produced**

91FE0086D Beijing GUANGMING RIBAO in Chinese  
15 Sep 90 p 1

[Text] The researchers at Sichuan Agricultural University [SAU] and Institute of Biology, Chinese Academy of Sciences, Chengdu Branch [IB, CASC] have successively

discovered new kinds of rice germplasm material—amixis rice—and have also gained important knowledge in the cytology, embryology and genetics of these materials. Recently, the experts in this field in the country have recognized these materials to certainly possess monogenetic reproductive characteristics after evaluating these materials in Chengdu. When applied in field production, they will help fix the superior quality of a hybrid by maintaining the hybrid's genetic makeup, and open a new route to increased production of rice.

The plant apomixis reproduction is a process of asexual reproduction without occurrence of fusion of male and female nuclei (fertilization). It can fix the superior quality of a hybrid for a long period without requiring continuous cross breeding and selection. It is said that in the world, there are more than 300 species of plants belonging to 36 families that have been found to have apomixis types. But until now, this phenomenon has not been observed in rice. Although the yield of a hybrid rice is high, due to its sexual reproduction, its hybrid superiority cannot be kept constant for long, and it has been necessary to strictly control its seed formation on a yearly basis. Thus the search for a rice amixis material which is high yielding and yet requires no controlled seed formation has become an important target for rice breeders worldwide.

The "Rice Genetics and Breeding" research project team with Professor Zhou Kaida of SAU as the principal investigator found a kind of amixis rice in an experimental rice field in Hainan Island in 1988, and named it SAR-1. Up to now, they have observed this line for five generations in seven seasons, and also have conducted close to 1 year's research on its cytology, etc. in cooperation with Sichuan University. They have proved that this material has a characteristic of monogenesis reproduction; i.e., it forms seeds without cell meiosis and fertilization. Its seeds are formed through the development of the embryos formed from mitosis of unfertilized ova. A line of male sterile rice variety C1001A discovered by IB, CASC in a rice field in its experimental farm in 1989 also shows phenomena of monogenesis and polyplasma formation which may be inheritable. Recently, the research projects of these two teams have respectively passed the evaluation step which was held by the team of experts in the first project of the National "863" Plan, Sichuan Science Committee, Sichuan Education Committee and CAS.

### **Biotechnology Research in CAS Shanghai Institute of Biochemistry**

91FE0086B Shanghai WEN HUI BAO in Chinese  
20 Sep 90 p 1

[by Ni Dazheng [0242 1129 2973]]

[Text] The researchers at the Chinese Academy of Sciences [CAS] Shanghai Institute of Biochemistry [SIB], aiming at the leading edge of international biological

high technology research, have secured rapid development in basic research. At the same time, confronting the main battleground of economic development, they have also achieved new accomplishments with important scientific significance and application values.

In recent years, scientists in the U.S., Japan and other countries have discovered that immunocompetent cells are capable of secreting a series of very strong anti-tumor and anti-toxin agents such as interleukin, interferon and tumor necrosis factor. These polypeptide drugs are the main objects of present genetic engineering R&D efforts that have gained the general attention of and fierce competition among the developed nations of the world. The research team 203 of CAS's SIB, under the leadership of Researcher Liu Xinyuan, has grasped the opportunity to meet the challenge. Presently they have attained new levels of expression rates of gene recombinant natural interleukin-2 and a new type of interleukin-2 in fermentation. Applying the internationally unique methods of isolation and treatment of inclusions developed by them, products with better than 95 percent purity have been obtained. The economic and social benefits of this work are obvious enough. In other work, after having artificially synthesized the gene of type r interferon in cooperation with the Genetics Research Institute of Fudan University, the team successfully linked it into a good expression carrier, causing the expression of the type r interferon to be more than 60 percent of the total protein content of the bacterium. In the pilot plant trial run this year, the yield per unit of fermentation solution was shown to be three times that which had been obtained at the laboratory stage, making it on par with the world's advanced level, thus creating a favorable condition for commercialized production. Cooperating with other teams of CAS's SIB, Researcher Liu Xinyuan has also carried out research on tumor necrosis factor and has made its expression reach the first class level internationally. This research will be transferred to the related research facility of the 2nd Military University to do further developmental pilot plant studies.

Site directional drugs, the so-called "biological missiles", are composed of two parts: a "directing system", i.e., a carrier; and a "missile head". These are targeting drugs that can kill cancer cells effectively but keep damage to the normal cells at a minimum. At CAS's SIB, Researcher Wang Qingcheng and others of Team 304, having first proved that bottle brush pollen protein can completely replace the commonly used immunotoxin "missile head"—a chain of castor bean toxin protein—have obtained, by group design and group effort, purer and biologically more active bottle brush pollen protein that has been shown to have a more than 90 percent tumor suppression rate at a dosage of 0.045 mg per rat (0.2 mg lower than the previous dosage). This apparent tumor suppression effect at such a low dosage of an immunotoxin has rarely been reported in the foreign literature. But the team was not satisfied. Very recently, it has isolated a new suppressing agent from a plant of

Curcubitaceae, whose biological activity is several hundred times that of bottle brush pollen protein. Its future is most promising.

Enzymes are the necessary research means for determining DNA structures. But enzymes generally lose their activity when the temperature exceeds 37°C. Researcher Hong Guofan and his Team 403 have increased the attractiveness of our country's cooperative programs with foreign researchers in S&T after they led the world in proposing the use of a high temperature enzyme to solve the problem of the occurrence of pinched structures during DNA sequencing. Early this year, with the effort of the team workers, this important research accomplishment led to a commercial product in the laboratory, joining the competition in the international market. More recently, Researcher Hong Guofan also obtained a breakthrough while engaged in biological nitrogen fixation by elucidating further the cause and effect at the molecular levels among three participants, the plant, signaling molecules and nitrogen fixing bacteria. This research accomplishment has created a new arena for the study of molecular biological nitrogen fixation. When the secret of biological nitrogen fixation is exposed, man will be able to change the nature of crops to assure abundant production and an abundant harvest.

### Industrialization of Biotechnology Achievements in Shanghai

91FE0086A Shanghai WEN HUI BAO in Chinese  
9 Sep 90 p 1

[by Yao Shihuang [1202 6108 3552]]

[Text] Scientists predict that the 21st Century will be the century of life science.

Biotechnology, which is based on life sciences, will be one of the fastest developing and the most promising of sciences and technologies for the next 20 to 30 years. It will help solve the problems of food and energy shortages, prevent diseases, elevate living and health standards and manage environmental pollution and other problems to bring forth a bright future for mankind.

At the present time, a fierce competition is taking place all over the world in the development of biotechnology. Biotechnology is fast becoming a new industry with great market potential. Whoever intensely cultivates the seedling of biotechnology today will be the one to control a strategic point of economic development tomorrow.

Shanghai is the first place in China to start to cultivate the seedling of biotechnology. Genetic engineering technology came into being for the first time in the early 70's in other countries, and by 1975, Shanghai had started its own research program. At the moment, Shanghai is the area where the strength of biotechnology in China is the strongest; it encompasses seven institutions of higher learning, 11 national research institutes and 15 local research institutes with a total of more than 6,000

research personnel. The research institutes of the Chinese Academy of Sciences [CAS] in Shanghai include Biochemistry, Cytology, Physiology, Pharmacology and Botany. These institutes and universities such as Fudan have assembled a group of the most renowned scientists in biotechnology in China; among them are 44 leading scientists of their respective disciplines in China. A considerable number of the young and middle-aged scientists have been sent abroad to study, conduct research and tour research facilities, and have attained considerable accomplishments.

Shanghai also excels over the rest of the country in developing biotechnological experiments, pilot plants and production. Among 10 of the most progressive open research laboratories in China, three in the biotechnology category are all in Shanghai. The CAS' Shanghai Biotechnology Center under construction can be said to belong to the first class in the world in its size and facilities. There are 70 enterprises producing biotechnology products in Shanghai at present. Many advanced products, such as penicillin O, semipenicillin O, glutamic acid, citric acid and lysine, all originated in Shanghai.

In recent years, many important achievements in the area of biotechnology that are of internationally advanced levels have come out from Shanghai. For instance, among the 15 most important achievements in genetic engineering—the leading technology of biotechnology—in China in the recent years, 10 have come from Shanghai, including gene clones of human cancer genes, rice plants from cell cultures and plant regenerations, human insulin, surface antigen for type B hepatitis toxin, penicillin O acylase, etc. The production bacterium developed by CAS' Shanghai Pharmacology Research Institute for the production of penicillin O acylase has been evaluated by the second trial run at the pilot plant. Its yield and other production criteria have been demonstrated to have reached the advanced international level. It has become the first possible industrial product in the medicinal field that applies genetic engineering in China.

When visiting various CAS' biotechnology research institutes, this reporter asked several researchers the question: "At the research level, how much is our country behind others?" The answer was: "In some areas we are behind, but in others, we are ahead. As a whole, we are not far behind, perhaps 2 to 3 years. But in industrialization, we are far behind, about 15 years." In 1989, of the total values of production and taxes paid on the profits from the products of bioindustries in Shanghai, those of the products of modern biotechnology were minuscule—0.54 and 1.29 percent, respectively.

How can we let the blooming flower of biotechnology become a plump, ripe fruit in Shanghai? This question has already attracted the attention of scientists, engineers and economists in Shanghai recently. Many experts point out that biotechnology has great economic

benefits for society. It has a wide open future regarding development and a definite great potential to become a leading industry of Shanghai. For example, if the diagnosis kit developed first in Shanghai for detecting hereditary DNA problems in the early stage of pregnancy is widely applied in the whole country, it can reduce the number of defective babies by some 10 million in the Seventh 5-Year Plan period, thereby saving various expenses amounting to 50 billion yuan and also be beneficial in upgrading the quality of the population. DNA polymerase lymerase, which has so far been produced in only a handful of countries, has been successfully test produced in Shanghai. It has wide applications in the production of early diagnosis kits for many difficult to treat diseases (including cancer and Alzheimer's disease), determining the sex of the fetus in domesticated animals, etc., and was internationally acclaimed as "heading the list of the 10 most important biotechnological accomplishments of 1989". The industrialists of Shanghai ought to open their eyes to adequately recognize the great significance of developing this new production technology with a huge market potential.

Experts in the field have also pointed out that the development of biotechnology requires the close cooperation of the research organizations and production enterprises. At the moment, the strength and the capital of Shanghai are still widely scattered. Disarray among educational, research, design, production, application and service organizations makes it impossible to have concerted action. These experts are of the opinion that to develop the biotechnology industry, Shanghai has sufficient facilities and personnel for research, pilot plants and production; the problem is in the lack of coordination, adequate support and nurturing. According to statistics, during the period 1981-1987, investment in biotechnology industries amounted to only 1.56 percent of the total investment in seven new technology industries in Shanghai. The relationship between research and production is akin to that of the upstream and the downstream of a river. In the investment and personnel allocation, it ought to be more toward the downstream. But it has become an "inverted pyramid" on the upstream side. There are numerous research institutions crowded with talent on one side, and on the other, in the downstream production part, due to lack of investment and talent, it cannot adopt the results of high technology. The experts have therefore proposed that a team of leaders be organized to coordinate industrialization of biotechnology. This will strengthen the organizational leadership, and the team will coordinate the strengths of all involved organizations by letting each research institute, institute of higher learning, and enterprise fully utilize its own superior ability in a rational, coordinated manner to cooperate in accelerating the process of industrialization. Investment in biotechnology industries must also be appropriately increased according to the needs and potentials.

In the past several years, the pace of industrialization of biotechnology has been extraordinarily fast. By the year

2000, the value of the products of modern biotechnology industries may exceed 60 billion U.S. dollars. Our Shanghai must heed this developmental trend, adequately apply and display our superiority, and make this new industry rise up quickly in Shanghai.

### STM Reveals New DNA Structure

91P60062A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 29 Nov 90 p 1

[Article by Huang Yong [7806 0516]: "Braid-Like, Three-Strand DNA Structure Uncovered Under Scanning Tunneling Microscope"]

[Summary] Dr. Bai Chunli [4101 2504 4409] of the Chemistry Institute of the Chinese Academy of Sciences and his colleagues uncovered a new DNA structure, a braid-like, three-strand chain structure, by direct observation under the scanning tunneling microscope (STM). The researchers started by heating DNA molecules to temperatures high enough to unwind the double helix structure and then let it cool. They then observed the DNA directly under the scanning tunneling microscope repeatedly. The mixed fragments of the braid-like, three-strand chain structure, the left-hand-side double helix structure, the connected sections of left-hand-side and right-hand-side double helices could be read clearly on the screen. This report has revealed the first discovery in direct observation of the dissociated DNA molecular structures under STM.

### Cell Culture Bioreactors Pass Appraisal

91P60062B Shanghai WEN HUI BAO in Chinese 30 Oct 90 p 1

[Article by Tao Hongguang [7118 3163 0342]: "Bioreactors for Culturing Animal Cells Pass Appraisal"]

[Summary] Bioreactors for large-scale animal cell culture have been developed by a research group led by Professor Ding Jianchong [0002 0256 2797] and Associate Professor Chen Yinliang [7115 0936 5328] of the Biochemical Engineering Institute of the East China Chemical Engineering College. Since bioreactors are essential for manufacturing high-efficiency medicines, sensitive diagnostic reagents, and other biological products, the subject of developing bioreactors for cell culture has been listed among key projects of the Seventh Five-Year Plan. By using reactors with large-area microcarrier system for cell growth and reactors with hollow cellulose tubes, the institute has been able to carry out mass production of biomedical products such as hepatitis B vaccine, encephalitis B vaccine, monoclonal antibodies, and interferons. These bioreactors have speeded up cell growth in the pharmaceutical manufacturing process and have greatly reduced costs of facilities imported from abroad. This achievement demonstrates that high-tech in the field of biotechnology in China now ranks among the world's advanced nations.

### Advances in Monoclonal Antibody Research

91P60062C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 12 Nov 90 p 2

[Article by Li Baoliang [0632 0202 5328]: "Monoclonal Antibody Research Ranks Among the World's Advanced"]

[Summary] Recently, achievements in monoclonal antibody (McAb) research passed appraisal at the military symposium for monoclonal antibody research. The McAb against specific type of hepatitis core antigen developed by the No. 302 Hospital of the People's Liberation Army is the most valuable accomplishment in providing an experimental measure for studying pathogeny and immune mechanism of hepatitis B infection. The No. 302 Hospital has established the conjugation test and conjugation-inhibition test for specific type of hepatitis, and also established the conjugation test and neutralization test against the specific type of hepatitis in order to further study the immunological regulation network and pathogenic mechanism of hepatitis B infection. The identification of new viral glycoprotein by the Fourth Military College using anti-Herpes simplex monoclonal antibody was a valuable discovery in the field of molecular biology. The success of the Fourth Military College's clinical treatment in rabbit keratitis caused by Herpes simplex virus by using anti-Herpes simplex McAb has opened up a new era for treating human blindness caused by this virus in China. The newly anti-cancer cell differentiation antigen McAb and immunotoxin for leukemia treatment and bone marrow transplants recently developed by the Academy of Military Medical Sciences are now under clinical tests, and the development of McAb for neutralizing leukemia cells from dyed interleukin-2 by the First Military College and the Academy of Military Medical Sciences has laid a solid foundation for leukemia diagnosis and treatment.

### Progress of Biomedical Technology in Guangdong

91FE0086C Guangzhou NANFANG RIBAO in Chinese 5 Oct 90 p 1

[Text] Since the Society of Biomedical Engineering was formed in Guangdong in August, 1980, education, research and production in this field have seen fast paced developments with many accomplishments which are to be congratulated.

First, both Zhongshan Medical University and Jinan University have established the curricula of biomedical engineering and research groups to train graduate students in biomedical engineering and develop research programs which have special emphasis. The Guangdong Institute of Cardiovascular Diseases has been engaged in research on artificial heart valves and the training of doctoral students. Guangzhou Medical College has established a medical imaging technology curriculum to train technologists in modern medical imaging technology. For the past 10 years, many research talents in science, engineering and medicine have switched to the



research, development and production in biomedical engineering, promoting the development of medical engineering in our province.

Second, due to cooperation among science, engineering and medicine professionals in the institutions of higher learning, large hospitals and manufacturing plants, the results of research have been quickly transferred into production. For instance, the pacemaker developed by

Zhongshan Medical University, Guangzhou Medical Instrument Plant and other related research institutes has a large market in the country after 10 years of continuing research and improvement to develop many different models. The Type I and Type II heart & lung machines developed by the provincial Institute of Cardiovascular Diseases, People's Hospital and Dongfanghong Medical Instrument Plant also have a large market in the country.

**Galaxy Supercomputer Seismological DPS in Operation 4 Years***91P60068D Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 9 Dec 90 p 2*

[Article by Zhou Hong [0719 1347] and Sun Yunliang [1327 6663 0081]: "Galaxy Seismological Data Processing System Manifests Invincible Might"]

[Summary] The Galaxy Seismological Data Processing System (DPS), put into operation 4 years ago, has been awarded a state S&T Advancement First Prize. The safeguard of this system, the Petroleum Exploration Bureau's research institute, has not only worked on a supercomputer supervisory program, but has also made several achievements at the world or domestic state-of-the-art.

The Galaxy Seismological DPS is the nation's largest electronic computer system, and includes the 100 MIPS "Galaxy" supercomputer as its host. Since 1986, this system has been used for processing data from tens of thousands of kilometers of sections taken from petroleum prospecting areas, resulting in a top-level product-quality rate of over 99 percent, and over 80 percent of the wells drilled based upon its calculations have yielded industrial-scale oil flows—among which certain wells in Xinjiang's Tarim Basin are a prime example—a much better rate than that permissible with mid-sized or minicomputer DPS's.

**Defense-Oriented Real-Time Operating System Developed, Copyrighted***91P60068C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 9 Dec 90 p 1*

[Article by Wang Hanlin [3769 5060 2651]: "China Has Its Own Computer Software Copyrighted"]

[Summary] The domestically developed "Military Real-Time Operating System" (RT/VMS for short), which passed the technical appraisal sponsored by the Commission of Science, Technology and Industry for National Defense (CSTIND) on 3 December, signifies China's entry into copyrighting of its own software, and has thereby built a line of defense to guard against computer virus [attacks and consequent data] destruction.

Military authorities predict that the threat of future wars will not be from atomic or hydrogen bombs, but from computer viruses. According to a military spokesman, a single computer virus released by a radar institute can cause an entire weapons command system to lock up. Almost all Chinese military and government decision-making authorities are now utilizing imported (or domestically assembled) computers, whose system software and support software are commercially copyrighted by foreign countries. Given the all-pervasive aspect of computer crimes and computer viruses today, the result of a situation wherein China's military secrets and important economic intelligence would be processed and

stored with hardware and software developed abroad would be hard to imagine. In a 5-year effort, a research team at CSTIND's Command Technology Institute led by Professor Meng Qingyu [1322 1987 0151] developed the new system, assigned as a Key State Seventh 5-Year Plan Project, via a comprehensive analysis of typical foreign military operating systems and an in-depth R&D program. Prof. Meng's achievement includes the development not only of the software version for a military real-time operating system, but also the development of an integrated system and environment.

RT/VMS will have immediate applications in spaceborne, warship-borne, and airborne command and control systems, as well as in real-time processing systems and other computer control systems in general. Experts at the appraisal commented that this system's development represents a major technological breakthrough in terms of time integration and processing technology, hardware/software channel interface technology, job scheduling, simulation of real-time scheduling in a non-real-time environment, low system overhead, and system hardware debugging technology.

**Neural-Net Chinese-Speech Recognition System Developed***91P60069A Beijing RENMIN RIBAO in Chinese 17 Dec 90 p 3*

[Article by Yang Zhaobo [2799 0340 3134]: "Neural-Net Techniques Successfully Used in Computer for First Time"]

[Summary] Beijing, 15 Dec (XINHUA)—Using artificial neural-network technology, scientists at the Chinese Academy of Sciences' Institute of Automation for the first time have perfected a computerized Chinese-speech recognition system, and based upon the system have developed a computerized voice-operated text-inputting system capable of recognizing over 20,000 dictionary entries. This "Chinese Dictionary-Scale Speech Recognition and Voice-Operated Text-Inputting System," whose development was a Key State Seventh 5-Year Plan Project, passed appraisal today. Experts noted that this state-of-the-art system's Chinese tone-recognition accuracy is over 99 percent, and its word-recognition accuracy is over 90 percent if compound words are used.

**Vector-Block Code Scheduling Implemented on Galaxy Supercomputer***91P60065A Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 18 No 6, Nov 90 pp 27-34 (MS received Apr 89, revised Jan 90)*

[Article by Zhang Kejun [1728 0668 6511] and Yang Taolan [2799 2711 2936] of Changsha Institute of Technology: "Code Scheduling of Vector Blocks"]

[Abstract] Various results of instruction (or code) scheduling in scalar blocks have been published<sup>1,2,5,12</sup> but they

cannot be used for vector blocks because the relationships among vector blocks are different from those among scalar blocks. Vector-block dependencies are analyzed in detail; using a Pascal description, a vector-block instruction-scheduling algorithm with an  $O(n^2)$  or  $O(n \cdot n)$  worst-case run time is proposed and implemented on the compiler of a 100 MIPS YH (Yinhe or Galaxy) supercomputer. By employing this scheduler, the object codes of vectorized loops can be re-sequenced to fully utilize the multi-functional pipelines and chaining characteristics of a pipelined computer so as to achieve greater parallelism.

One of the steps may be omitted when implementing the algorithm on a Cray X-MP, Cray 2, or YH-2 [i.e., Galaxy II]; but on a Cray 1, YH-1, or similar supercomputer, vector poke instructions cannot be chained,<sup>3,7</sup> so the step must be included for them. Results of actual runs indicate that execution times for standard Cray 1 routines<sup>8</sup> can be reduced to various extents: the V.STORE V12,D instruction is reduced from 717 pipeline beats to 478; the VF.MUL V12,V5,V11 instruction is reduced from 644 beats to 381 beats; the VF.MINU V11,V5,V2 instruction is reduced from 580 beats to 321 beats; etc.

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#### Defense-Oriented C-Ada Compiler Developed

91P60078A Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 44,  
14 Nov 90 p 1

[Article by Liu Jiuru [0491 0046 1172]: "Mainframe Software C-Ada Compiler System Developed"]

[Summary] A C-Ada compiler system, developed by the Commission of Science, Technology and Industry for National Defense (CSTIND) as a military common-software project, passed MMEI-sponsored technical appraisal the other day. This C-Ada compiler is the nation's first fully integrated C-language-developed UNIX-environment Ada compiler, and has its own copyright. The target code generated by this compiler is suited for parallel execution by currently widespread multiprocessor systems; according to the available documents investigated, it is the world's first Ada compiler to simulate a multiprocessor environment on a single-processor computer system.

Over 4,200 modules in this C-Ada compiler have passed rigorous testing with the ACVC 1.10-version verification [software] set published by the U.S. DOD in 1989, thus certifying the compiler to current international standards. Principally responsible for this compiler's development are 12 researchers from MMEI's North China Computing Institute, who spent three years and 10 months to write the 210,000-plus lines of code.

#### Shenzhen 386 High-Performance Microcomputer Workstation From CAS

91P60068A Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese  
2 Dec 90 p 3

[Article by Li Qiongrui [2621 8825 3843] and Li Kunkun [2621 2492 2492]: "386 Microcomputer Workstation and Microcomputer System Developed"]

[Summary] The CAS 386 high-grade microcomputer workstation and microcomputer system, officially called the "Shenzhen [4377 1558] 386 Universal-Style Workstation," developed jointly by three CAS institutes (Computing, Automation, and Software), passed CAS-sponsored design finalization on 26 November. This new workstation and system, which offers high-grade

workstation performance at high-grade microcomputer cost, is oriented toward industry CAD/CAM users and will be further developed and marketed by the Zhongdian S&T Development Corporation.

Maximum transmission rate between the 33 MHz 386 CPU and memory is 66 Mbits/s. The system has a high-speed floating-point processor (FPP) built around RISC chips and parallel-processing technology; this FPP raises processing power by one order of magnitude. Also included are a newly designed intelligent disk-control card and intelligent I/O card, which greatly increase system throughput, and an independently designed high-resolution (1280 x 1024) color graphics control card. Operating under UNIX, this state-of-the-art system is ideal for office automation, scientific computation, and engineering.

#### **Advanced Printed-Chinese-Character Recognition System in Batch Production**

91P60068B Beijing KEJI RIBAO [*SCIENCE AND TECHNOLOGY DAILY*] in Chinese 6 Dec 90 p 1

[Article by Ji Hongguang [1323 3163 0342]: "Printed-Chinese-Character Recognition System at World State-of-the-Art"]

[Summary] Chinese scientists have made a major breakthrough in information recognition technology: the HQ-1 printed-Chinese-character recognition system developed over a 5-year period by Hebei University Associate Professor Guo Baolan [6753 1405 5695] passed the technical appraisal given by an expert group on 29 November in Beijing, and is now formally in batch production at the Beijing Qike [1142 4430] Electronic New Technologies Ltd. plant.

While studying cutting-edge computerized word-recognition technology at Shizuoka University in Japan, Prof. Guo invented two patented techniques: the "forgiving matching selection method" and the "double-key-point forgiving matching selection method," which have been successfully applied to a computerized system for recognizing printed Hebrew words and now one for Chinese characters. When Prof. Guo returned to China from Japan, she donated to her native land [China] the intellectual property rights to her inventions. With four of her colleagues, she then developed the "point-tracking forgiving matching selection method" and the "correlated Chinese-character recognition method." Prof. Guo's new system recognizes simplified or traditional Chinese characters in various major typefaces at a rate of 1300 per minute (50-60 times the rate of the best human inputting techniques) with a recognition accuracy of 95 percent; the system runs on a 20MHz 386 microcomputer. Experts have noted that the appearance of Prof. Guo's system is a major step forward for the development of China's intelligent computer technology.

#### **First National Neural-Network Conference Held**

91P60078B Beijing ZHONGGUO DIANZI BAO [*CHINA ELECTRONICS NEWS*] in Chinese 16 Dec 90 p 3

[Article by Lin Feng [2651 2800] and Jin Jianzhong [6855 1696 0022]: "First Chinese Neural-Network Conference Convened"]

[Summary] China's first neural-network academic conference, called by members of the China Electronics Society, Artificial Intelligence Society, Psychology Society, Computer Society, Biophysics Society, Automation Society, Physics Society, and Communications Society, was held on 10-13 December [1990] in Beijing. Representatives from almost 100 research institutes and institutions of higher education across the country attended the conference, at which were published 358 technical papers on such topics as brain functions and biological neural-network models, artificial neural-network theory and models, new algorithms, neurocomputers, VLSI circuits and optical implementation, associative memory, neural networks and artificial intelligence, neural networks and signal processing, neural networks and pattern recognition, neural networks and automatic control, and neural networks and communications.

#### **Sea-Wave Data Processing System Developed**

91P60078C Beijing JISUANJI SHIJIIE [*CHINA COMPUTERWORLD*] in Chinese No 49, 19 Dec 90 p 3

[Unsigned article: "More Achievements in China's Sea-Wave Research"]

[Summary] Since the publication in 1949 of N. F. Barber's study of a diffraction method for analyzing sea-wave [photographic] negatives, the study of the application of optical methods in determining the direction of sea waves has been an interesting topic. In the Sixth Five-Year Plan, researchers from Fudan University and the Maritime University in Qingdao studied optical/digital hybrid methods and all-digital methods for determining wave direction, wave distribution, and wave-height classification. In the Seventh Five-Year Plan [1986-1990], researchers from Fudan University's Computer Science Department and Electronic Engineering Department successfully undertook a key state project to develop a "Sea-Wave Information Processing Method and System"; this system passed the expert technical appraisal sponsored by the Shanghai Municipality Office of Higher Education a few days ago.

The system includes an F-P [Fabry-Perot] interferometer, which is a nonlinear optical device used to compensate for the nonlinearity of the Fresnel-reflection curve. The 1024 x 1024 [pixel array] spectral detection system has a directional accuracy of 1° and employs digital image-processing technology. Via a fast superposition algorithm and one-dimensional FFT [Fast Fourier

Transform], one can directly compute the directional spectrum. The system runs on an IBM PC/XT and meets 1980's international standards. Utilizing this system for spectral estimation of a two-dimensional 512 x 512 image array, with 16 azimuthal numbers, requires nine minutes, with a wave directional accuracy of  $\pm 6^\circ$ ; with 32 azimuthal numbers, time required is 18 minutes and wave directional accuracy is  $\pm 3^\circ$ . The system has applications in wave research, wave forecasting, marine engineering, shipping, navigation, offshore-oil-platform construction, and the military.

#### **Logical Inference Language, System Debut**

91P60078D Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 24 Dec 90 p 1

[Article by Wang Yiwei [3769 0076 5898] and Dai Meihua [2071 5019 5478]: "General-Purpose Logical Inference Language and Its Implementation System Debut"]

[Summary] A general-purpose logical inference language TUILI [Pinyin for "inference"] and its implementation system passed the technical appraisal sponsored by the Chinese Academy of Sciences' (CAS) Office of Mathematical Physics and Chemistry a few days ago. This revolutionary new language—superior to PROLOG—was designed by Prof. Lu Ruqian [7120 3067 6870] of the CAS Institute of Mathematics. Synthesizing various artificial-intelligence inferential functions with a language useful for knowledge-engineering applications, TUILI is a general-purpose expert-system description language, which can be referenced with the C or

PROLOG languages. The creation of such a language and system has not heretofore been reported at home or abroad.

#### **Communications Network Study for Military Fuzzy-Information Decision-Support System**

91P60078E Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 25 Dec 90 p 1

[Article by Lin Feng [2651 2800]: "Key CSTIND Design Project: Communications Random Network Reliability Analysis Produces Innovative Results"]

[Summary] A fuzzy-information-processing command decision-support system and communications random-network reliability analysis study passed technical appraisal in Beijing on 6 December. The technical experts at the appraisal felt that this major achievement—undertaken by the Ministry of Machine-Building and Electronics Industry's (MMEI) Electronics Industry Computing Center as a key research project for MMEI in the Seventh Five-Year Plan—is at the cutting edge of computer research, and is the first of its kind reported worldwide.

The goal of this research is to investigate the application of fuzzy-set theory to processing of imprecise information in communications random networks used for military command decision-support. In a three-year effort, researchers at the aforementioned computing center developed the theory of and several utility [computer] programs for analyzing the reliability and life cycle of a fuzzy random network.

## Domestic CIMS Projects Described

### Advances In, Future Development of CIMS

91P60067 Beijing JICHUANG [MACHINE TOOLS]  
in Chinese No 10, Oct 90 pp 4-5

[Article by Fan Hongcai [5400 1347 2088] of the Ministry of Machine-Building & Electronics Industry (MMEI): "Integrate National Conditions; Develop China's CIM Technology"; first installment in a continuing series entitled "How To Implement Chinese-Style CIMS"]

[Summary] In March 1987, the national government passed the State High-Tech Development Plan, which includes two automation-related areas: computer integrated manufacturing systems (CIMS) and intelligent robotics. The goal of these projects is to increase China's competitiveness in the high-tech sector by narrowing the gap between our nation and the technologically advanced nations. By the year 2000, China will have completed construction of its CIMS pilot (demonstration) plants. Responsible for these projects is an expert group in automation technology under the guidance of the State S&T Commission. The CIMS research facilities include an engineering center at Qinghua university and seven laboratories.

Early preparatory work [c. 1980] centered around absorption of imported technology such as CAD systems. This was followed by the introduction of management technology, such as the Shenyang No. 1 Machine Tool Plant's importation of a computerized production management information system (MIS) from the FRG in the early 80s. MMEI's Institute of Automation has been studying MIS-MRP-II [MIS-Manufacturing Resources Planning II] technology since that time, and some firms have already implemented such systems. Other businesses, universities, and research institutes have implemented independently developed versions of CAPP-GT [computer-aided process planning—group technology], resulting in tangible benefits, and Jinan No. 1 Machine Tool Plant imported and put into operation a CIR-GT [computer integrated resources—group technology] system from Great Britain in the mid-80s.

Another part of the entire picture is NC and CNC machine tools, of which China has manufactured over 300 mid-to-high-quality units annually over the past few years; in addition, a significant number of CNC machine tools have been imported in the same period. Also, China has imported four FMSs [flexible manufacturing systems]; Beijing Machine Tool Research Institute has its cooperatively designed and developed FMS, and a number of other firms will put FMSs into operation in the early 90s.

Any domestic development of CIMS should be suitable to China's national conditions, should be based on demand, and should generate benefits. What is needed is a unification of all the various technologies—CAD/CAM, MRP II, CAPP-GT, CAQ [computer-aided

quality assurance], CAT [computer-aided testing], etc.—via techniques such as distributed databases for resource sharing; these databases can gradually be networked with NC and CNC machine tools. Much work in the area of software development remains to be done, and investment in only a little hardware requires great sums. China must focus on substantial results, not superficial engineering modifications. The introduction of computer technology and flexible automated manufacturing equipment must be oriented toward the unified overall management inherent in the CIMS concept.

### Beijing Plant Passes Feasibility Appraisal

91P60067 Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 4 Oct 90 p 1

[Article by Yang Jingyi [2799 2529 1355] and Yu Shiyong [0151 2514 5391]: "Beijing No. 1 Machine Tool Plant Passes State CIMS Feasibility Expert Appraisal"]

[Summary] Beijing No. 1 Machine Tool Plant's CIMS cell-technology key applications plant recently passed state CIMS feasibility expert appraisal. On the basis of positive results from an experimental phase, during which network node technology was introduced, the project—along with others in the nation—is now moving into a phase of actual development and application.

As the nation's largest manufacturer of milling machines, the Beijing plant has combined CAD and computer-aided management into "cell technology." The project's scope includes computerized overall integration of design, technology, product manufacturing, quality assurance, finances, supply, and sales management. This CIMS cell technology will greatly reduce new-product trial-manufacturing periods and introduce highly modernized management and automation methods—including flexible manufacturing lines—that can furnish valuable experience to other enterprises in the nation.

### Chengdu Aircraft Company's Project Advances

91P60067 Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 8 Nov 90 p 2

[Article by Zhang Xiaoyuan [1728 2556 0626]: "Chengdu Aircraft Industrial Company's Automated Engineering Project Rapidly Advances"]

[Summary] After its inclusion in 1989 by the national government in the 863 Plan, the automated CIMS plant project of the Chengdu Aircraft Industrial Company (CAC) has been rapidly advancing. In early May of this year [1990], the CAC CIMS feasibility demonstration passed national-level appraisal, and the project is now in the initial design phase, with the first functional model already completed.

According to the specialists, the 863 Plan Automated-Areas CIMS Experimental Project is a unified plan integrating engineering design, production processes and

production management. This intelligent-computer-controlled project is geared toward production of military and civilian aeronautical and non-aeronautical products for the domestic market, as well as for the international market under subcontracting arrangements. As part of the project, the CIMS expert group has imported a Manufacturing Resource Planning (MRP-II) system. Work on developing a Chinese-made version of this system has already begun, and when the work is completed CAC will have attained a technological level on a par with that of advanced nations in the 1980s.

#### **Four Key Projects Pass State Feasibility Demonstration**

91P60067 Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 46,  
28 Nov 90 p 1

[Unsigned article: "Nation's Enterprise Automation Strides into New Phase"]

[Summary] (XINHUA)—Four key applications plants converting to CIMS technology have separately passed the feasibility demonstrations conducted by the State S&T Commission. They include the Chengdu Aircraft Co., the Jinan No. 1 Machine Tool Plant, The Shanghai No. 2 Textile Machinery Plant, and the Shenyang Blower Plant. Strategic goals, demonstrations of the overall plans, and overall design of the experimental engineering have been completed for all projects, and the initial steps toward implementation of the cell technology are currently being taken.

The Shenyang Blower Plant, in business for 50 years, is the nation's largest designer and manufacturer of turbo compressors and turbo blowers. Over the past few years, the plant has gained experience from the introduction of

plant-wide production MIS and CAD/CAM workstations. This has reduced product delivery times from the original 20-24 months to about 18 months; annual output value has increased from some 50 million yuan in 1985 to over 100 million yuan last year [1989]. The Shanghai No. 2 Textile Machinery Plant, utilizing computer group cell technology for business management, has taken over the leading spot nationwide for worker productivity among firms in its field.

According to information released by the State S&T Commission, these four key projects will complete their [initial] phased targets by 1993. By the end of the century, these four enterprises will have become "automated self-sufficient islands," incorporating four subsystems—integrated management information, integrated manufacturing engineering, integrated flexible machining, and integrated quality management, all with computer networks, databases, and simulation [software]—and will have attained a level comparable to that of advanced nations as of the early 90s.

#### **Additional Details on Four Key Projects**

91P60067 Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 28 Nov 90 p 1

[Article by Jiang Min [1203 2404]: "Four High-Tech Key Applications Plants Begin to Gear Up"]

[Summary] The Shenyang Blower Plant, whose annual output value has increased from 50.36 million yuan in 1985 to over 100 million yuan in 1989, is annually saving the state U.S.\$12 million by replacing imports. Jinan No. 1 Machine Tool Plant, by applying NC technology, has already produced over 100 NC machine tools this year [1990], constituting an NC rate [i.e., proportion of NC machine tools produced among all machine tools produced] of 10 percent.

### Two New Defense-Oriented High-Power Lasers Developed

91P60086 Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 27 Dec 90 p 1

[Article by Zhu Shi [6999 4258]: "Another New Breakthrough in National Defense Research"]

[Summary] The "high-average-power continuously excited [neodymium] yttrium-aluminum-garnet [Nd:YAG] laser" and "high-average-power pulsed Nd:YAG laser" developed by MMEI's Research Institute 11 have passed design finalization. Experts at the formal appraisal commented that these two achievements match the state-of-the-art.

The short-wavelength solid-state high-average-power Nd:YAG laser, which incorporates a fiber-optic waveguide, has a strong, compact structure and is highly vibration-resistant and shock-resistant, making it excellent for laser machining and for military applications. Development of such a laser has been a source of intense rivalry in Europe, the U.S., the USSR and Japan; in Europe, for example, the EUREKA Program has allocated US\$23 million over a 5-year period for the development of such a high-power solid-state laser. The domestic development of the model JYL-2 continuously excited Nd:YAG laser and high-average-power pulsed Nd:YAG laser is a major breakthrough for defense research, with applications in laser machining of high-strength, high-hardness, high-melting-point metals. In addition, China's first maximum-power pulsed YAG laser machining apparatus employs the model JYM-10 high-average-power pulsed Nd:YAG laser as its light source.

### RCS Compact Test Range Developed

91P60076D Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 21 Dec 90 p 3

[Article by Li Qi'an [2621 0796 1344]: "Armaments Industry's First Electromagnetic Wave Chamber Completed at Xian"]

[Text] The armaments industry's first electromagnetic wave chamber, independently designed and constructed by Chinese engineers, was completed the other day at Xian Research Institute 212, and passed technical appraisal on 16 November. Experts at the appraisal agreed that in its key technical indicators—dead-zone reflected voltage, intrinsic radar cross-section (RCS) and shielding performance—this chamber has attained an international state-of-the-art level.

The chamber can be used for restricted-space simulation of unbounded aircraft free-flight; for debugging of a variety of aircraft systems or components; for measurements of antenna radiation directionality, antenna impedance, and coupling between antennas; for measurement of the effective RCS of various targets; and for

testing the electromagnetic compatibility of various items. The chamber has a 150 MHz-40 GHz operating frequency range, and a large bandwidth.

Experimental use of this chamber began in 1987; in that year, Canadian professors and Chinese researchers from the Ministry of Aeronautics and Astronautics Industry's Research Institute 710 utilized the chamber in the first successful domestic tests of microwave three-dimensional imagery from five kinds of targets of varying diameter—single spheres, twin spheres, aircraft models, etc. Last year, utilizing the chamber to test various aircraft, guided missiles, and rockets under different attitude characteristics, the researchers obtained several thousand bits of data which will provide a scientific basis for optimizing the design of high-tech products.

### CW Diode Laser-Pumped Nd:YAG Laser

91FE0154A Shanghai YINGYONG JIGUANG [APPLIED LASER TECHNOLOGY] in Chinese Vol 10 No 5, Oct 90 pp 193-194 [MS received 18 Jun 90]

[Article by Pan Yong [3382 8673] and Shen Guanqun [3088 0385 5028] of Shanghai Institute of Laser Technology: "CW Diode Laser-Pumped Nd:YAG Laser"]

#### [Text] Abstract

A semiconductor laser with a nominal wavelength of 0.78  $\mu\text{m}$  was used to end-pump a Nd:YAG rod and continuous wave (CW) output of 1.064  $\mu\text{m}$  laser was obtained.

A great deal of progress has been made in taking advantage of the characteristics of a semiconductor laser, such as long lifetime, high efficiency, stability, and narrow and tunable output spectrum, to pump a solid state laser.<sup>1,2</sup>

As semiconductor and solid state lasers make advances, the direction of development abroad in areas such as Q tuning, mode locking and frequency doubling is toward high power, commercial products.<sup>3,4</sup> This makes it very promising to use a semiconductor laser to pump a solid state laser.

In the past, a semiconductor laser with a nominal wavelength of 0.81  $\mu\text{m}$  was used. In addition, the semiconductor laser was cooled in order to match with the main absorption peak of Nd:YAG crystal at 807 nm. Furthermore, the CW output of a semiconductor laser is usually greater than 15 mW. It is very easy to buy a 0.78  $\mu\text{m}$  nominal wavelength diode laser with 3-5 mW of output power. To date, no one has used it as a light pump source to obtain CW output of a solid state laser. This type of short wavelength, low power diode laser was used to end-pump a Nd:YAG laser and CW output at 1.064  $\mu\text{m}$  was realized.



### Technical Considerations

To use a short wavelength, low power semiconductor laser as the light pump source for a Nd:YAG laser, it is necessary to solve a number of technical issues such as wavelength matching and reduction of laser threshold power.

Figure 1 shows the absorption spectrum of Nd:YAG doped at 1 percent level. We can see that, in addition to the 807 nm main absorption peak, there are two secondary absorption peaks at 792 and 795 nm. In order to better couple the pumping spectrum with the absorption spectrum of the crystal, we employed a temperature adjustment method. It was experimentally determined that the temperature coefficient of the output wavelength of a diode laser is approximately  $0.3 \text{ nm}/^\circ\text{C}$ . At  $30^\circ\text{C}$  and  $40^\circ\text{C}$ , the diode laser spectra coincide with that of Nd:YAG at 792 nm and 795 nm and the absorption coefficients are  $2.5 \text{ cm}^{-1}$  and  $3.0 \text{ cm}^{-1}$ , respectively.

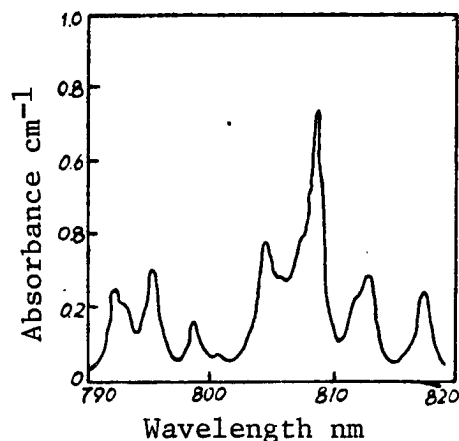


Figure 1

Longitudinal pumping was used to fully utilize the brightness from the diode laser to allow the pumping beam to better couple with the laser oscillation mode. Therefore, it is a low threshold, high efficiency pumping method.

For an end-pumped laser, its threshold power is:<sup>5</sup>

$$P_{th} = \frac{h\nu_p \delta}{2\sigma\tau} \frac{\pi}{2} (\bar{\omega}_0^2 + \bar{\omega}_p^2)$$

where  $h\nu_p$  is the pumping photon energy,  $\delta$  is the total cavity loss,  $\sigma$  is the net gain cross-section which is usually  $4.0 \times 10^{-19} \text{ cm}^2$ ,  $\tau$  is the lifetime of upper energy level which is  $230 \mu\text{s}$ ,  $\bar{\omega}_0$  and  $\bar{\omega}_p$  are the radii of the laser beam and pumping beam, respectively, and  $P_{th}$  is the amount of pumping energy required to be absorbed in order to reach the threshold. From the equation, we can see that in order to lower the threshold, it is necessary to reduce the mode volume and loss. This can be accomplished by 1) using a monolithic laser structure to eliminate loss due

to out-of-tune of the resonance cavity, 2) choosing small  $\bar{\omega}_0$  and  $\bar{\omega}_p$ , and 3) using the shortest crystal length possible while ensuring sufficient pumping energy can be absorbed.

### Experimental Results

In this experiment, a small monolithic Nd:YAG oscillator was fabricated. The laser rod is 6 mm long and 5 mm in diameter and both ends are curved with a radius of curvature of 18 mm. One end was coated with a dielectric film which is highly reflective at  $1.06 \mu\text{m}$  and highly transmissive at  $0.79 \mu\text{m}$ . On the other end, the dielectric film transmits 0.4 percent at  $1.06 \mu\text{m}$  and is highly reflective at  $0.79 \mu\text{m}$ . This resonance cavity has a Gaussian mode waist radius of  $35 \mu\text{m}$ .

Figure 2 shows the experimental apparatus. The semiconductor diode laser and the lens are assembled into a laser emitting head. The outer jacket of this laser emitting head contains heating elements and a thermistor. A temperature control circuit is used to tune the wavelength of the diode laser. Its temperature fluctuation is less than  $0.5^\circ\text{C}$ . The coupling efficiency of the diode laser through the lens is approximately 50 percent. The laser can be focused to a  $27 \mu\text{m} \times 30 \mu\text{m}$  spot which is comparable to the waist of the solid state laser.

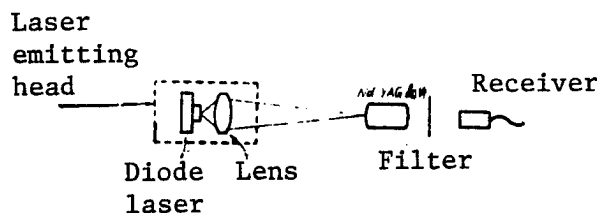


Figure 2

When the coupling between the diode laser and the oscillating mode of the solid state laser is good and when the output wavelength is at 792 nm or 795 nm, the Nd:YAG crystal can output CW laser at  $1.064 \mu\text{m}$  in TEM mode. It was experimentally determined that the threshold pumping power delivered to the front of the Nd:YAG laser is approximately 2.1 mW. When the diode laser is operating at full load, the optical power incident upon the front surface is 3.1 mW. At this time, the solid state laser output is approximately  $70 \mu\text{W}$ .

In order to further enhance the power output of the solid state laser, we used two diode lasers to simultaneously pump a laser rod. A polarizing prism was used to merge two different linearly polarized diode laser beams into one. It was experimentally proven that pumping could be increased by approximately 1.9 times.

This method also creates conditions for gain switching and mode locking studies. The authors wish to thank Senior Engineer Cao Peiqi [2580 3099 0366] for his assistance.

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**H/LJP-343A Radar Passes Appraisal**

91P60098A Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
30 Dec 90 p 2

[Article by Zuo Guoshun [1563 0948 7311] and Cao Wenxi [2580 2429 0823]: "H/LJP-343A Radar Passes Appraisal"]

[Summary] The H/LJP-343A radar, developed by the state-run Changzhou Radio Plant, recently passed first-unit-off-factory-line appraisal. An improved version of the original model 343 radar, this new model is a noncoherent instantaneous-tracking digital frequency-agile radar, and comes equipped with a laser distance gauge and a television tracking instrument.

**New 1.5-Micron-Wavelength Tunable External-Cavity Semiconductor Laser Developed**

91P60098A Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese 6 Jan 91  
p 3

[Article by Li Qiongrui [2621 8825 3843]: "1.5-Micron Single-Mode Narrow-Linewidth Tunable External-Cavity Semiconductor Laser Developed"]

[Summary] A 1.5-micron-wavelength single-mode narrow-linewidth tunable external-cavity semiconductor laser diode developed by researchers at Qinghua University's Electrical Engineering Department as a State Seventh 5-Year Plan priority project and as an "863" Program high-tech project passed expert technical appraisal on 28 December 1990. This frequency-stabilized long-wavelength laser diode is critically needed as a light source for frequency-division multiplexing and coherent optical communications technologies. Laser-diode linewidth is less than 60kHz, tunable range is greater than 100 nanometers, and 24-hour frequency drift is less than 30MHz. According to nationally prominent optoelectronics specialist Professor Ye Peida [0673 1014 1129], the head of the expert appraisal group, this device is at the international state-of-the-art.

**Multielement TeSnPb Infrared Detector Developed**

91P60076C Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
21 Dec 90 p 3

[Article by Li Qiongrui [2621 8825 3843]: "MMEI's Research Institute 11 Develops Multielement Tellurium-Tin-Lead Detector"]

[Summary] A high-sensitivity multielement infrared detector—the model HFX-3 16-element TeSnPb infrared detector—was recently developed by MMEI's Research Institute 11, and on 12 December passed MMEI-sponsored design finalization. The technical experts at the design finalization agreed that it meets standards for like products produced abroad in the early eighties.

This key component in night-vision devices—which make it possible to see targets such as men, motor vehicles, or aircraft in darkness—is a PbTe/TeSnPb [lead telluride/tellurium tin lead] heterojunction photovoltaic-type detector. On the TeSnPb monocrystalline substrate, a thin film of TeSnPb was epitaxially grown, followed by an epitaxially grown film of PbTe monocrystal. The detector operates principally in the 8-12-micron-wavelength infrared band, has a detectivity ( $D^*\lambda P$ ) of  $2.75 \times 10^{10} - 7 \times 10^{10}$  cm-Hz<sup>1/2</sup>/watt, and a responsivity of 2,700 volts/watt. The device has been tested experimentally in an infrared forward-looking system and in the [Earth] Resources 1 Satellite's No. 2 principles demonstrator, with the following results: at a distance of 150 meters, men walking at night on a road could be clearly seen, planes landing at night could be easily tracked, and infrared remote-sensing photographs of roads and bridges taken from an altitude of 2,600 meters revealed various structures or different pieces of equipment at a glance.

**Three Key Radar Components Accredited**

91P60076B Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
16 Dec 90 p 1

[Article by Liu Keli [0491 0344 7787]: "Three Kinds of Radar Key Components Pass Appraisal"]

[Summary] Three key radar components developed by the Chinese Academy of Sciences' (CAS) Institute of Electronics—a high-power klystron, a traveling-wave [klystron] tube, and a switching tube—passed CAS-level technical appraisal on 28 November. These three components, totaling five models, are the highest quality devices of their kind in China, and will form a basis for domestic development of complete radar systems suitable for the nineties. Receiver sensitivity has been greatly increased and operating voltage has been reduced, while band-holding has not changed.

In a 2-year effort, the CAS Institute of Electronics incorporated in the klystron such advanced technologies as the overlap-style coupled-cavity output method to realize a 1 dB bandwidth exceeding 7.5 percent at an output power of 1 megawatt. This demonstrates that domestic radar high-power klystrons have reached the worldwide state-of-the-art. In its development of the second key component, a traveling-wave klystron, the institute incorporated new technologies such as clover-leaf slow-wave circuits; moreover, the institute has made the transmission from the development phase to the commercialization phase. Export of all these products will generate significant foreign exchange for the state.

### **Chongqing To Be Major Center of CCD Technology Development**

91P60076A Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
11 Dec 90 p 1

[Article by Ren Guangquan [0117 0342 3123]: "Chongqing To Focus on Developing CCD Technology"]

[Summary] During the Eighth 5-Year Plan, the Chongqing area will be a leading center of R&D of CCD [charge-coupled device] technology. This information was disclosed on 25 November by Chongqing Vice Mayor Qin Changdian and by representatives of the Commission of Science, Technology and Industry for National Defense (CSTIND). Participating enterprises in the Chongqing area include the Huashu [5478 5771] Optoelectronics Group and MMEI's Research Institute 44.

The main source of investment funds for the development of CCD industrial technology will be the city coffers. Also, the Huashu Group has entered into a joint venture—U.S. TCC Electronics Ltd.—with the U.S. firm TCI Co., and has imported a CCD production line capable of an annual output of 2 million B&W/color devices.

Additional dispatch: The CSTIND-organized CCD Image Pick-Up Device Key Project Applications Conference convened on 25 November in Chongqing. Over 80 specialists from 48 Chinese research institutes and institutions of higher education attended the conference, at which were published 23 papers on domestic and foreign CCD technology. In addition to CSTIND members,

representatives of the State Planning Commission, the State S&T Commission, and MMEI also attended.

### **Technical Details Released on PRC-Brazilian Remote-Sensing Satellites**

91P60092 Beijing SHIJIE DAODAN YU HANGTIAN  
[MISSILES & SPACECRAFT] in Chinese No 2, Feb 90  
pp 5-6, 11

[Article by Fu Wenlong [0102 2429 7893]: "Current Status of, Future Prospects for Sino-Brazilian Space Cooperation"]

[Summary] The Sino-Brazilian project to develop two China-Brazil Earth Resources Satellites (CBERS) is a joint undertaking of CAST (Chinese Academy of Space Technology) and Brazil's INPE (National Institute for Space Research). Of the US\$150 million joint funding, China is responsible for 70 percent and Brazil for 30 percent; the total investment figure includes funds for the two launch vehicles (Long March 4's, manufactured by the Shanghai Astronautics Bureau) and satellite launch services, as well as for the two remote-sensing CBERS themselves.

CBERS-1 and CBERS-2 will be launched into an 800-km-altitude sun-synchronous orbit. Basic parameters of the satellites are as follows:

Size: 2m x 1.8m x 2.2m

Weight: 1400kg

Stabilization method: 3-axis stabilized

Total power (minimum output): 985 watts

Radio frequencies: UHF/VHF, S band

Each satellite will carry aboard two imaging devices: (1) a CCD [charge-coupled device] camera, sensitive in the 0.51-0.89-nanometer-wavelength visible range, with five windows in all, a ground resolution of 20 meters, and a side-looking ability; and (2) an infrared multi-spectral-scanner camera operating in the 0.5-12.5-nanometer wavelength range, with four windows in all and a ground resolution of 80 meters.

The launch of CBERS-1 is [as of this time, i.e. February 1990] planned for mid-1993.

**Three New Semiconductor Lasers Developed**

91P60077d Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
21 Dec 90 p 3

[Article by Wu Ruisheng [0702 3843 3932]: "Three New Kinds of Semiconductor Lasers Developed"; also see JPRS-CST-91-001, 4 Jan 91, pp 18-19, an early report which incorrectly indicated the number of new semiconductor lasers developed as "two".]

[Summary] Three new kinds of semiconductor lasers—a distributed-feedback (DFB) diode laser, an uncooled diode laser (in two different operating wavelengths), and an optically bistable diode laser—developed by the CAS Institute of Semiconductors have now been accredited.

The first type, a 1.55-micron-wavelength DFB diode laser, is a grating feedback diode laser which can operate with single-longitudinal-mode output at high-frequency (over 1GHz) modulation. Developed as part of the State's "863" High-Tech Plan, this device was fabricated via ion etching and two-step epitaxy, and has a ridge-waveguide and planar mask buried-ridge structure. The device's room-temperature typical threshold current is 15 milliamps (mA), linear output power exceeds 2 milliwatts (mW) and is typically in the 3-5-mW range, main-to-side-mode ratio is 25dB, dynamic bandwidth at a frequency modulation of over 1GHz is less than 3 angstroms, and operating life at 20°C is greater than 1000 hours. This device is an ideal light source for 140Mbit/s [DS4] fiber-optic communications systems.

The second type, a single-mode uncooled diode laser available in both 1.3-micron and 1.55-micron operating wavelengths requires no special cooling and therefore reduces power consumption. It has a low threshold current (30mA) and a long operating life (over 50,000 hours). After growing the buried region, the researchers etched a narrow arrow-shaped trench, and in the trench grew a crescent-shaped active region to form the BH [buried heterostructure or buried heterojunction] structure, fabricated on a P-type substrate. These diodes are now in small-batch production, and the 1.3-micron uncooled diode laser in a To package has been exported to Canada.

The third type, a 1.3-micron-wavelength InGaAsP/InP optically bistable diode laser—a key element in digital optical information processing, optical computing, and optical communications systems—has a planar mask BH common-cavity-two-section design and was fabricated via liquid-phase epitaxy. Typical transmitting-state threshold current for this low-threshold device is 40 milliamperes [sic; probably 40mA]. This state-of-the-art bistable diode laser is suitable for optical switching systems.

**New Optoelectronic-Device Material Developed**

91P60077a Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
14 Dec 90 p 3

[Caption to photograph by He Chunfan [0149 2504 5672]]

[Text] A multielement antimonide material—double-heterostructure GaInAsSb/AlGa(As)Sb/GaSb material—used in fabricating optoelectronic devices employed in long-range optical communications has been developed by the Chinese Academy of Sciences' Institute of Semiconductors, and meets international standards for the mid-to-late eighties. The photo [not reproduced] shows the specialists at the technical accreditation as they observe the techniques for growing this material.

**Scientist Formulates Two Laws for Gate-Type Memory Circuits**

91P60077b Zhengzhou HENAN RIBAO in Chinese  
16 Dec 90 p 1

[Unsigned article: "Zhang Zongxue Formulates Two Laws for Gate-Type Memory Circuits"]

[Summary] Beijing, 14 Dec (XINHUA)—PLA Surveying & Cartography Institute Assistant Professor Zhang Zongxue [1728 1350 7185] has realized a major scientific achievement in his formulation of two laws for gate-type memory circuits. This achievement will provide a path whereby China's microelectronics industry can catch up to the state-of-the-art. In his research on gate-type memory circuits beginning in 1980, Prof. Zhang conducted over 600 experiments to provide data from which he formulated his "Gate-Type Stable Memory Circuit Law" and "Gate-Type Temporary Memory Circuit Law." Experiments have demonstrated that application of Prof. Zhang's two laws can permit each element on an IC to perform from four to 16 functions, which will increase IC speed, decrease power consumption, and reduce circuit volume and manufacturing costs.

**New Quantum-Well IR Detector Developed**

91P60077c Beijing BEIJING KEJI BAO [BEIJING SCIENCE & TECHNOLOGY NEWS] in Chinese  
19 Dec 90 p 1

[Article by Zhou Wenlei [0719 2429 4320]: "New Quantum-Well Infrared Detector Domestically Developed for First Time"]

[Summary] A new type of quantum-well infrared (IR) detector, developed for the first time worldwide in the late eighties, has now been developed domestically by the CAS Institute of Physics. The quantum-well IR

detector, as opposed to the widely used HgCdSb IR detector, utilizes semiconductor superlattice quantum-well structures.

The GaAs/AlGaAs quantum-well IR detector developed by the CAS Institute of Physics has the following parameters: at a temperature of 77K, load resistance is 10 ohms; at a bias voltage of 2V, current responsivity is 5V/W; and peak response wavelength is 10.68 microns. The institute is currently working on improving the material's structure and fabrication technique in order to further improve performance.

### Semi-Insulating GaAs Impurity Defect Study Passes Appraisal

91P60077f Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese  
25 Dec 90 p 1

[Article by Xie Yannan [6043 3601 0809]: "Semi-Insulating Gallium-Arsenide Impurity Defect Research Passes Appraisal"]

[Summary] A key State Seventh 5-Year Plan project to study EL<sub>2</sub> centers, metastable-state deep centers, and shallow impurity characteristics in semi-insulating (SI) GaAs crystals passed appraisal on 12 December in Tianjin. This project, undertaken by MMEI's Research Institute 46, includes use of room-temperature and low-temperature infrared absorption techniques to measure impurity and defect concentrations in SI GaAs in order to improve techniques for growing GaAs monocrystal.

### Transport Properties of GaAs/AlGaAs Quantum Well

40100024A Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese  
Vol 11 No 10, Oct 90 (manuscript received 27 Dec 89)  
pp 727-732

[English abstract of article by Wang Xinghua and Zheng Houzhi, (National Laboratory for Superlattice and Related Microstructures and Institute of Semiconductors, CAS, P.O. Box 912, Beijing, China)]

[Text] Scattering mechanisms have been studied for low-mobility GaAs/AlGaAs quantum-well samples. Transport scattering time  $\tau_o$  and relaxation time (quantum scattering time)  $\tau_q$  have been obtained by measuring the conductivity and Shubnikov-de-Haas oscillation envelope, respectively. The results show that  $\tau_o \approx \tau_q$  for quantum-well samples, for modulation-doped GaAs/AlGaAs heterostructures; however,  $\tau_o \gg \tau_q$  has been observed. These experimental results are explained by two different kinds of dominant scattering mechanism in quantum wells and heterostructures.

Negative magnetoresistance has also been investigated in GaAs/AlGaAs quantum wells. It results from the suppression of the localization in two-dimensional electron system by magnetic field.

### LEP Growth and Characterization of AlGaAsSb Epilayers

40100024B Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese  
Vol 11 No 10, Oct 90 (manuscript received 12 Feb 90)  
pp 738-745

[English abstract of article by Yang Baohua, Wang Zhanguo, Wan Shouke, Gong Xiuying and Lin Lanying, (Institute of Semiconductors, CAS, Beijing)]

[Text] Lattice-matched AlGaAsSb quaternary epilayers have been grown on GaSb substrates at 530°C by LPE [liquid phase epitaxy]. The band gaps and lattice parameters of these layers are determined by room-temperature photoluminescence and X-ray double crystal diffraction measurements, respectively. The electrical properties are assessed by C-V and Van der Pauw methods. In addition, laser Raman scattering and low-temperature photoluminescence measurements were carried out. The GaSb-like LO mode, AlSb-like LO mode and the coupled mode between LO phonon and plasmon are observed. The temperature coefficient of the energy gap is determined to be  $-3.2 \times 10^{-4}$  eV/K for epilayer with  $x = 0.2$ ,  $y = 0.025$ .

### LPE Growth and Properties of In<sub>x</sub>Ga<sub>1-x</sub>As<sub>y</sub>Sb<sub>1-y</sub> Lattice-Matched to (100) GaSb

40100024C Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese  
Vol 11 No 10, Oct 90 (manuscript received 13 Oct 89)  
pp 746-750

[English abstract of article by Liu Xuefeng, Gong Xiuying and Wang Zhanguo, (Institute of Semiconductors, CAS, Beijing)]

[Text] In<sub>x</sub>Ga<sub>1-x</sub>As<sub>y</sub>Sb<sub>1-y</sub> epitaxial layers lattice matched to (100) GaSb substrates have been successfully grown in a composition range ( $0 < x < 0.17$ ,  $0 < y < 0.12$ ) by LPE [liquid phase epitaxy] technique. Double-crystal X-ray diffraction measurements show that the minimum lattice mismatch,  $< 2 \times 10^{-4}$ , can be reached if the liquid compositions are carefully designed. The 80K cathodoluminescence spectra on these epitaxial layers indicate that the bandgap energy range is from 1.733 eV 0.635 eV, and the longest peak wavelength of 1.95  $\mu$ m has been reached with the maximum solid composition  $x = 0.17$ ,  $y = 0.12$ . Infrared absorption spectrum of this epilayer shows an emission wavelength of 2.18  $\mu$ m at room temperature.

### Design of Long-Wavelength InGaAs/InGaAsP/InP Avalanche Photodiodes With Separate Absorption, Grading and Multiplication (SAGM) Regions and Step-Like Kinks of I<sub>p</sub>-V Curve

40100024D Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese  
Vol 11 No 10, Oct 90 (manuscript received 22 Aug 89, revised 11 Mar 90) pp 773-779

[English abstract of article by Ding Guoqing, (Wuhan Telecommunications Devices Co.)]

[Text] The device parameters of a InGaAs/InGaAsP/InP SAGM-APD are designed and estimated according to the requirements of the avalanche field and the field-limiting tunneling current in the device. Two kinks of the  $I_p$ -V curve were observed and explained. We have shown that the suitable ratio of  $V_{th}/V_B$  is about one third, and an empirical formula is found, which is in agreement with the measured results of Mp.

#### **A New Transient C-V Method for Study of DX Centers in $Al_xGa_{1-x}As$**

40100025A Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 11 No 11, Nov 90 (manuscript received 24 Aug 89, revised 15 May 90) pp 809-821

[English abstract of article by Jia Yingbo, (Graduate School, University of Science and Technology of China, Beijing, China); Li Mingfu, (Graduate School, University of Science and Technology of China, Beijing; Institute of Semiconductors, CAS, Beijing; and Department of Physics, Fudan University, Shanghai, China); Zhou Jie, Gao Jilin and Kong Meiyang, (Institute of Semiconductors, CAS, Beijing, China)]

[Text] We present in this paper the importance of the edge region in capacitance measurement of DX centers and the improvement of the step-wise charge distribution of the edge region. A new transient C-V method is used to measure the density of DX centers, density of bulk electrons in the conduction band and the space-charge distribution in the depletion region at a constant reverse bias. The temperature dependence of the density of bulk electrons in the conduction band has also been obtained. The thermal ionization energy of DX centers can be derived from these results. A comparison of the experiments and the theoretical curves derived from the negative U and positive U models of DX centers has been made and the conclusions are consistent with our previous analysis of Hall experiments. In order to fit the theoretical curves to the experimental data, compensating acceptors in the case of +U model, or other kind of shallow donors in the case of -U model should be considered.

#### **Measurements of Hot Electron Magnetophonon Resonance in $GaAs/Al_xGa_{1-x}As$ Heterostructures**

40100025B Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 11 No 11, Nov 90 (manuscript received 1 Nov 89) pp 829-833

[English abstract of article by Cheng Wenchao, Li Yuexia and Liang Jiben, (National Laboratory for Superlattices and Microstructures and Institute of Semiconductors, CAS, Beijing)]

[Text] The magnetophonon resonance of 2D hot electrons in  $GaAs/Al_xGa_{1-x}As$  heterostructures is measured under high electric fields at 4.2K. Besides LO phonon

oscillation, double TA phonon oscillation has clearly been observed at X point, after SdH oscillation disappeared.

#### **X-Ray Double-Crystal Diffraction Study of $In_xGa_{1-x}As/GaAs$ Strained-Layer Superlattice**

40100025C Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 11 No 11, Nov 90 (manuscript received 24 Jan 90) pp 855-858

[English abstract of article by Chen Jingyi, Zhu Nanchang, Tian Lianguang and Li Runshen, (Shanghai Institute of Metallurgy, CAS, Shanghai, 200050, China)]

[Text] A computer simulation method based on X-ray dynamical diffraction theory is presented. The method is used for the analysis of X-ray double-crystal rocking curves of superlattices. The structure parameters of the  $In_xGa_{1-x}As/GaAs$  strained-layer superlattice is obtained from the simulation of the rocking-curve.

#### **Crystalline Quality Study of MBE Ga-As-on-Si Through High-Energy Ion Implantation and Subsequent Annealing**

40100025D Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 11 No 11, Nov 90 (manuscript received 18 Jan 90) pp 866-870

[English abstract of article by Xiao Guangming, Yin Shidian, Zhang Jingping and Fan Tiwen, (Institute of Semiconductors, CAS, China); Liu Jiarui, Ding Aiju, Zhou Junming and Zhu Peiran, (Institute of Physics, CAS, China)]

[Text] 4.2MeV  $^7Li$  channeling techniques and laser Raman scattering spectrometry have been utilized to study the regrowth of MBE-GaAs films on Si substrates by MeV  $Si^+$  implantation and subsequent rapid infrared thermal annealing. Complete regrowth has been obtained when a buried amorphous layer was formed at the GaAs/Si interface and annealed at 850°C for 15s. Crystalline disorder is greatly reduced in the recrystallized layers especially at the interface. When  $Si^+$  implantation dose exceeds a certain critical value, which leads to severe local nonstoichiometry, incomplete regrowth occurs. The results of Raman scattering show that the ratio of TO/LO decreases significantly after annealing.

#### **Novel Method for Fabricating Higher Mobility MOSFET's**

40100025E Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 11 No 11, Nov 90 (manuscript received 26 Jun 89) pp 877-880

[English abstract of article by Long Wei and Xu Yuansen, (Shanghai Institute of Metallurgy, CAS)]

[Text] The MOSFET's and MOS capacitors with HF[hydrogen-fluoride]-doped thin oxides have been shown to have excellent electrical characteristics. The effective surface mobilities of such HF-devices are 1.7-2.4 times higher than those of conventional devices over the channel effective field range studied. It indicates that MOS devices with higher speeds could be achieved by HF-enhanced oxidation.

**Polarization and Longitudinal Mode Characteristics of InGaAsP/InP CCTS Bistable Laser**

40100024E Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese  
Vol 11 No 10, Oct 90 (manuscript received 6 Nov 89)  
pp 790-794

[English abstract of article by Li Jianmeng and Wang Qiming, (Institute of Semiconductors, CAS, Beijing)]

[Text] This paper gives the polarization and longitudinal mode characteristics of a InGaAsP/InP CCTS [common-cavity two-section] bistable laser. It is concluded that the saturable absorber plays a major role in selecting the cavity mode operation in a bistable laser. Its major effect is on the mode discrimination and mode group operation, i.e., TE or TM.

**Shanghai Institute Steps Up Development of ASICs**

91P60077e Shanghai WEN HUI BAO in Chinese  
24 Dec 90 p 1

[Article by Wu Yingxi [0702 5391 3556]: "Vigorously Develop ASICs, Promote Transformation of Traditional Industrial Technology"]

[Summary] The Shanghai Microelectronics R&D Center, jointly funded and established by the Chinese Academy of Sciences (CAS) and Shanghai Municipality, has developed over 100 types of ICs and won State S&T achievement awards. Recently, the State Planning Commission has singled out the institution as one of the four key national microelectronics R&D centers for state funding. This center was formed around the CAS Shanghai Institute of Metallurgy's microelectronics division.

In the past few years, with the difficulty of obtaining application-specific integrated circuits (ASICs) on the international market due to their custom-made nature, the institute has developed and commercialized 46 new types of ASICs used in transforming traditional industry. Examples include ASICs for machine-tool digital displays, for computers, for mid-to-high-quality "Seagull" automatic cameras made at the Shanghai Seagull Camera Plant, and for Chinese-English typewriters.

**World Records for Critical Temperature, Critical Current Density Remain**

91P60090 Beijing RENMIN RIBAO in Chinese  
8 Jan 91 p 4

[Article by Wang Yougong [3769 0645 1872]: "Nation's High-Temperature Superconductivity Technology Achievements Are Outstanding"]

[Summary] Beijing, 7 Jan—Over a period of 3 years, the nation's scientists in the field of high-temperature superconductivity have been world leaders for their achievements in materials, devices, and basic research.

The absolute temperature of 132K for a high-critical-temperature superconductor—a value achieved by Chinese scientists—remains the world record so far. Also, a critical current density (an important indicator of superconductivity for bulk materials) of almost 70,000 amperes per square centimeter—the latest value achieved by the nation's scientists for a YBaCuO material, at a temperature of 77K and in the presence of a 10,000-gauss magnetic field—is the highest value attained in the world to date.

Domestic superconductivity research has received Party Central Committee and State Council support, including establishment of a State Superconductor Technology Expert Commission and a State Superconductor Technology Joint R&D Center; there is also the State Superconductivity Laboratory under CAS's Institute of Physics. Altogether, almost 20 research units nationwide are participating in the cooperative project.

**Developments in SQUID Technology Reported****High-Tc-Superconductor Refrigerators Accredited**

91P60075A Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
9 Dec 90 p 3

[Article by Yang Tianxin [2799 1131 0207]: "High-Tc-Superconductor Suo-er-wen and Non-Magnetic Refrigerators Pass Appraisal"]

[Summary] Developed by MMEI's Research Institute 16, two new kinds of high-Tc-superconductor refrigerators—a Suo-er-wen [phonetic; perhaps Salwin] type and a non-magnetic type—passed technical appraisal in Hefei a few days ago. The high-Tc-superconductor Suo-er-wen refrigerator is a closed-loop continuous low-temperature cooling apparatus. The non-magnetic refrigerator is a practical cooling source for applications of high-Tc-superconductor devices. Uses are for weak-magnetic-field detection, airborne mineral prospecting, anti-submarine detection, medical treatment, and related areas. The technical experts positively confirmed the results of the institute's application of the refrigerator in developing SQUIDS [superconducting quantum interference devices], and hoped that further testing would improve quality.

**High-Tc SQUID, Microwave Resonant Cavity Accredited**

91P60075B Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
21 Dec 90 p 3

[Article by Yang Tianxin [2799 1131 0207]: "High-Tc SQUID, Microwave Resonant Cavity Pass Expert Appraisal"]

[Summary] The high-Tc SQUID and high-Tc-superconductor microwave resonant cavity developed by MMEI's Research Institute 16 passed expert appraisal in Hefei the other day. The high-Tc SQUID, which can withstand a 300K to 77K recycle, is applicable to magnetic anomaly detection, low-frequency communications, anti-submarine detection, and other areas, and meets late-eighties international standards. The high-Tc-superconductor microwave resonant cavity is an exceedingly useful superconducting microwave passive device with a high quality factor; it has applications as a frequency-stabilized oscillator and as a two-stage frequency standard.

**Investigation on High Tc Superconductor of Bi(Pb)-Sr-Ca-Cu-O and Improvement of Critical Current Density**

40090005B Beijing DIWEN WULI XUEBAO  
[CHINESE JOURNAL OF LOW TEMPERATURE  
PHYSICS] in Chinese Vol 12 No 6, Nov 90 pp 417-422

[English abstract of article by Zhou Eyou, Wu Meiyang, Sun Yue, Wu Yixiong, Wei Wangshui, and Hu Suhui of the Shanghai Institute of Metallurgy, Academia Sinica, Shanghai, 200050]

[Text] The effect of adding Pb, heat treatment and cold drawing technique on the superconducting properties and microstructure of Bi(Pb)-Sr-Ca-Cu-O were investigated. It was found that the fraction of 2212 phase can be reduced by sintering the sample near the melting temperature followed by an annealing. However this was improved more effectively by the additional element of Pb. As a result, the  $J_c$  value in Ag-sheathed tape can be raised to 7950 A/cm. The main reason for the enhancement of  $J_c$  is attributed to the grain alignment with c-axis oriented preferentially vertical to the surface of Ag-sheathed tape.

**Electronic Structure of High Temperature Superconducting Sc-Y-Ba-Cu Oxide: Substitution of Y Sites With Sc**

40090005A Beijing DIWEN WULI XUEBAO  
[CHINESE JOURNAL OF LOW TEMPERATURE  
PHYSICS] in Chinese Vol 12 No 6, Nov 90 pp 407-416

[English abstract of article by Wang Huaiyu, Zhang Liyuan, Liu Fusui, and Wang Enge of the Department of Physics, Beijing University, Beijing, 100871]



[Text] The electronic densities of states in  $\text{YBa}_2\text{Cu}_3\text{O}_7$  and  $\text{Y}_{0.5}\text{Sc}_{0.5}\text{Ba}_2\text{Cu}_3\text{O}_7$  crystals are calculated in a tight binding approximation by the recursion method for solving Schrodinger Equation. Taking into account of the crystal field splitting in Cu sites and using corrected hopping integral parameters, we have achieved better calculative results of  $\text{YBa}_2\text{Cu}_3\text{O}_7$  crystals. The substitution of Y sites by Sc does not have much effect on the electronic structure. If the possible effect on oxygen deficiency concentration is neglected, Sc substitution itself does not obviously result in the change of Cu atomic valences.

**Superconductivity and Magnetic Order in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$**

40090005D Beijing DIWEN WULI XUEBAO  
[CHINESE JOURNAL OF LOW TEMPERATURE  
PHYSICS] in Chinese Vol 12 No 6, Nov 90 pp 468-471

[English abstract of article by Wen Haihu, Zhang Fengying, and Cao Xiaowen of the Institute of Plasma Physics, Academia Sinica, Hefei, 230031]

[Text] Two resistance transitions have been observed on a Y-Ba-Cu-O film, one occurs in the region from 120 K to room temperature, and another always at 90 K. Experiments of both tiny magnetic torsion balance and A. C. susceptibility have shown that the large drop of resistance at high temperature is accompanied by ferromagnetism ordering, while the jump of resistance

occurred near 90 K is a superconducting transition. The authors think that the ferromagnetism ordering occurred at high temperature is related to the full ordering of the oxygen vacancies and the ratio of  $\text{Cu}^{3+}/\text{Cu}^{2+}$ .

**A Study of Valency of Cu and O Ions in High Tc Superconductor  $\text{YBa}_2\text{Cu}_3\text{O}_7$**

40090005C Beijing DIWEN WULI XUEBAO  
[CHINESE JOURNAL OF LOW TEMPERATURE  
PHYSICS] in Chinese Vol 12 No 6, Nov 90 pp 423-430

[English abstract of article by Pan Wei and Zheng Qingqi of the Institute of Solid State Physics, Academia Sinica, Hefei, 230031]

[Text] The cluster model is used to study the valency of Cu and O ions in high Tc superconductor  $\text{YBa}_2\text{Cu}_3\text{O}_7$ . The electronic structure and valency are obtained by solving the one electron equation self-consistently in the frame of local density functional theory. In this article we discuss in detail the influence of electronic distribution of the environmental ions around the cluster on the valency of Cu and O ions. The calculated and obtained results reveal that the valency of all Cu ions are +2 while the holes are located at oxygen sites, which is in good agreement with the experimental results. For four different kinds of oxygen sites, the holes distribute mainly at the O(4) sites in the Ba-O layers, and the distribution of holes can be disturbed easily by the change of the environmental electron distribution of ions around the cluster.

## Developments in Fiber-Optic Communications Reported

### DS4 Optical Terminal Equipment Accredited

91P60074A Beijing DIANXIN JISHU  
[TELECOMMUNICATIONS TECHNOLOGY]  
in Chinese No 12, Dec 90 p 45

[Untitled news brief by Yu Mou [1342 6180] and Jiang Shui [3068 3055]]

[Text] Sixteen kinds of DS4 [140 Mbit/s, 1,920 voice circuits] optical-terminal special-purpose modules, jointly developed by MPT's Chongqing Communications Equipment Plant and MMEI's Research Institute 13, passed the technical appraisal sponsored by the State S&T Commission in Shijiazhuang City at the end of August. DS4 optical terminals are a national Torch Plan item. It is estimated that construction of the modularized DS4 optical terminals at the Chongqing Communications Equipment Plant will be completed by year's end [1990], and that the units will be on the market next year [1991].

### Shanghai-Nanjing Trunkline To Be Built

91P60074B Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
11 Dec 90 p 1

[Article by Jiang You [3068 1429]: "Shanghai-Nanjing Fiber-Optic Cable Communications Trunkline To Be Built"]

[Summary] During the Eighth 5-Year Plan, China will construct a 402-km-long Shanghai-Nanjing fiber-optic-cable communications trunkline. The project design passed technical appraisal on 12 November, and laying of the line will begin in early 1991. Completion of first-phase construction will mean the opening up of 15,000 new long-distance lines. It is understood that this project is a continuation of the about-to-be-completed Nanjing-Wuhan line.

### Cable-Core Filling Oil Passes Appraisal

91P60074C Nanjing JIANGSU KEJI BAO in Chinese  
12 Dec 90 p 1

[Article by Xiao Dongquan [5135 2767 0356]: "Opening Up Fiber-Optic-Cable Communications"]

[Summary] The fiber-optic-cable cable-core filling oil developed by the Taihu Communications Materials Plant in Wuxi County passed the expert technical appraisal sponsored recently by the State Education Commission and is now in batch production. This high-tech product, meeting late-eighties international standards, is designed for protecting undersea and deeply buried fiber-optic cables and was developed with the aid of the East China Chemical Institute, the Shanghai Cable Plant, and other institutions.

### First Domestic Undersea Cable Laid

91P60074D Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 13 Dec 90 p 2

[Article by Jin Congan [6855 1783 1344] and Chen Jingnong [7115 2417 6593]: "Laying of China's First Undersea Fiber-Optic Cable Completed"]

[Summary] Laying of China's first functional undersea fiber-optic cable, jointly developed by MMEI's Huainan Research Institute 8 and Hubei Province's Hongqi Cable Plant, was officially completed on 18 November at Qingdao. This 33-km-long, four-core single-mode fiber-optic cable has a 1.3-micron operating wavelength, an average transmission loss of 0.377 dB/km, and a maximum transmission loss of 0.46 dB/km. Under a tension of 15 tons, elongation of this steel-wire-reinforced cable is only 0.35 percent.

### Beijing-Baoding Railroad's Special System

91P60074E Beijing ZHONGGUO DIANZI BAO  
[CHINA ELECTRONICS NEWS] in Chinese  
18 Dec 90 p 1

[Article by Ge Xiuhan [5514 0208 3466]: "Railroad-Use DS3 Fiber-Optic Communications System Passes Appraisal"]

[Summary] The Beijing-Baoding Railroad DS3 [34 Mbit/s, 480 voice circuits] fiber-optic communications system, developed by the Nanjing Wired Telecommunications Plant, passed MMEI-sponsored technical appraisal in Nanjing on 6 December. This 154-km-long system for providing long-haul communications to railroad authorities includes advanced equipment such as microcomputer monitoring stations.

### Digital Fiber-Optic Communications Test Equipment Developed

91P60089 Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 27 Dec 90 p 1

[Article by Ji Hongguang [1323 3163 0342]: "China's Digital Communications Testing Technology Enters World's Advanced Ranks"]

[Summary] Beijing, 26 Dec—During the Eighth 5-Year Plan [1991-1995], China will construct a nearly 70,000-kilometer-long digital fiber-optic communications network, in which about 20 percent of engineering investment will go toward transmission test instruments, heretofore manufactured only by three nations in the world—the U.S., Japan, and Germany. Faced with the problem of continuing outlays of foreign exchange for importation of such instruments, MPT in 1986 undertook a major Seventh 5-Year Plan project to utilize the nation's own resources toward development of these instruments, a project which has now been completed.

The instruments which have just passed technical appraisal include a digital transmission system analyzer for DS1-DS4 [DS1 = 2Mbps, 30 voice circuits; DS2 =

8Mbps, 120 voice circuits; DS3 = 34Mbps, 480 voice circuits; DS4 = 140Mbps, 1920 voice circuits] systems, a DS4 phase jitter analyzer, and a DS5 [565Mbps] (7680 voice circuits) bit-error-rate analyzer. The MPT unit responsible for development of these instruments is the Beijing Instruments & Meters Research Institute, which not only produced the sample instruments, but also put

them into batch production. Experts at the technical appraisal commented that the nation's digital fiber-optic communications testing technology now stands in the world's front ranks, and that the appearance of these domestically made instruments will provide a major boost to China's development of DS5 systems, as well as save the state major outlays of foreign exchange.

### Technical Details of First Pulsed Reactor Released

91P60096 Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 28 Dec 90 p 3

[Article by Deng Xianchun [6772 6343 2504]: "Nation's First Pulsed Reactor Completed"]

[Summary] Construction of the nation's first pulsed reactor was recently completed at the Southwest Center for Reactor Engineering Research & Design (SWCR). China thereby becomes the second nation in the world—after the U.S.—to master this new reactor design and manufacturing technology.

The completion of this research nuclear reactor— independently designed and built over a 10-year period by specialists at SWCR, an affiliate of the [China National] Nuclear Industry Corp.—indicates the successful resolution of problems involving special fuel-element design and manufacturing, pulse parameter measurement techniques, design theory, and computational programs. Operating in any of four modes— manual, automatic, pulsed, and square-wave—the reactor has a steady-state operating power of 1000 kilowatts, a pulse peak power of 3420 megawatts, and a maximum pulse peak neutron fluence rate [i.e., neutron flux density] of  $6 \times 10^{16}$  neutrons/cm<sup>2</sup>/second.

### YAG Laser Device Said To Be at International Levels

91FE0195C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 17 Nov 90 p 1

[Article by correspondent Shi Jianping [4258 1696 1627]: "China's Laser Devices Said To Be At World Level"]

[Text] Since undertaking the "High-Average-Power Pulsed YAG Laser Machining Device" project assigned by the State Education Commission as a key Seventh 5-Year Plan project in 1986, the 11th Institute of the Ministry of Machine-Building and Electronics Industry has worked hard to develop China's first high-average power Nd:YAG laser machining device, the GLL-1, by relying on its own technical strength. Its overall performance is at international level. On this basis, different models and specifications can be designed to meet various user requirements for use in production and research. It is well praised and positively recognized by electromechanical experts from all over China.

Laser machining in other countries began in 1970. It is an important field of applied laser technology. Due to its unique advantages, it can be widely used in every field in the national economy. In other countries, pulsed YAG lasers with a mean power of 400 W and above are already commercially available. The development of high-average-power pulsed YAG laser in China began in the middle 1980's. With the exception that Shanghai Institute of Optics and Fine Mechanics and Tianjin Laser

Institute imported the LMC-24 laser from Raytheon and 400 W YAG laser machining device from JK Corporation, there is no other report on its research and manufacture in China. The pulsed laser developed by the 11th Institute of the Ministry of Machine-Building and Electronics Industry has a maximum mean output power of 800 W. Its single pulsed output energy is over 98 joules. The efficiency of the laser is 3.9 percent. Its positioning accuracy is high. The machine can operate continuously for 16 hours. It is suitable for industrial applications in mechanical, electronics, aerospace, instrumentation and light industries to solve technical problems that cannot be dealt with by conventional methods. For instance, it can cut the hardest artificial diamond, weld metal such as tungsten and rhenium with a melting point above 3300 °C, weld dissimilar, and drill holes as small as 0.1 mm in diameter on metals or other materials. The successful development of this laser laid the foundation for high power solid state laser machining technology. It is a positive step to replace similar high power solid laser machining units that are being imported.

### All-out Effort To Develop Controlled Fusion Technology

91FE0195B Beijing GUANGMING RIBAO in Chinese 5 Nov 90 p 1

[Article by Liu Jingzhi [0491 2417 1807]: "All-out Effort To Develop Technology Associated With Controlled Fusion"]

[Text] During a recent visit to China's largest Tokamak apparatus for controlled fusion research, "China Circulator No. 1 [HL-1]," we discovered that Southwest Physics Institute of the Nuclear Industry Corporation not only made significant progress in controlled fusion research but also successfully devoted a great deal of effort to pursue applications of intermediate technology associated with fusion based on the guideline of "engaging in a variety of businesses centered around nuclear industry to benefit economically."

The institute successfully developed an ion implantation machine based on plasma technology to modify the surface characteristics of metals for improved erosion and corrosion resistance in order to lengthen product life. It is successfully used in implantation studies with hardened alloy blades, drill bits for printed circuit boards and artificial joints.

The institute also applies its high power electromagnetic technology to successfully develop a rotating dual chamber magnetron sputtering coating machine. It is capable of putting a uniform metallic coating not only on a metal surface but also on ceramics, glass and engineering plastics.

Furthermore, there is no contamination. It is well liked by end users. Based on its ultrahigh vacuum technology, an automatic circulating helium low temperature condensation adsorption pump was developed. It has

achieved 1980 level and has a wide range of applications in aerospace, microelectronics and electric vacuum technology.

In addition, they employed nuclear particle technology and fusion-related microcomputer and electronic control to develop an advanced digital vacuum gauge, a photoelectric meter counter, a large area arc ion coating machine and a magnetometer for fundamental structure examination.

Experts revealed that controlled fusion is a high technology in the future. It is estimated to be in actual use by 2030. Nevertheless, as a leader, it brings about a number of high technologies. These intermediate technologies would play an important role in the growth of our national economy.

#### **Update on Southwest Physics Institute Fusion Research**

*91FE0195a Chengdu SICHUAN RIBAO in Chinese  
20 Nov 90 p 1*

[Article by correspondents Li Qiming [2621 0796 2494] and Qing Yuanshu [7230 6678 2873]: "Successful Application of Nuclear Fusion Technology Developed by Southwest Physics Institute"]

[Text] In addition to focusing on basic research, Southwest Physics Institute is actively pursuing applications for technology associated with nuclear fusion and has developed a number of high-tech commercial products. Between January and August 1990, the institute manufactured commercial products worth 2.63 million yuan.

Southwest Physics Institute is primarily engaged in basic applied research. It has designed and constructed an

experimental device for controlled fusion, i.e. "China Circulator No. 1 [HL-1]," and was given a first class national S&T progress award. In response to the reform of the S&T system, the institute is following the instruction of the China Nuclear Corporation to "combine military and civilian applications, center around nuclear industry, and engage in a variety of businesses to order to do well economically." While keeping its focus still on basic fusion research, it is pursuing applications for intermediate technology associated with fusion in order to promote the development of commercial products. Intermediate technology associated with fusion includes everything that is developed as a result of nuclear fusion research, such as plasma technology, ultrahigh vacuum technology, low temperature superconductivity technology, high power electromagnetic technology, etc. In recent years, the institute has developed nine high tech products, including a rotating dual chamber sputtering coating machine, single beam (ion beam) and triple beam (ion, atom and electron beam) implantation machine, digital vacuum gauge, automatic circulating helium low temperature condensation adsorption pump and vibration magnetic field gauge. The coating machine, implantation machine, vacuum gauge and low temperature pump have been accredited by the ministry. Significant economic benefits have resulted from their use. For instance, the ion implantation machine is primarily used to modify the surface characteristics of metals to improve erosion and corrosion resistance. Compared to conventional heat treatment, it is a "cold treatment," which has no effect on the dimensions and precision of the part. This machine has been successfully used in production. The triple beam ion implantation machine and the vibration magnetic field gauge are being exported.

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